"CAHALL"

Fifth Edition, March, 1900

Cahall

Water Tube Steam Boilers

Manufactured by

The Aultman & Taylor
Machinery Company

Mansfield, Ohio

Thayer & Co., Incorporated

General Eastern Agents

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Cahall Sales Department

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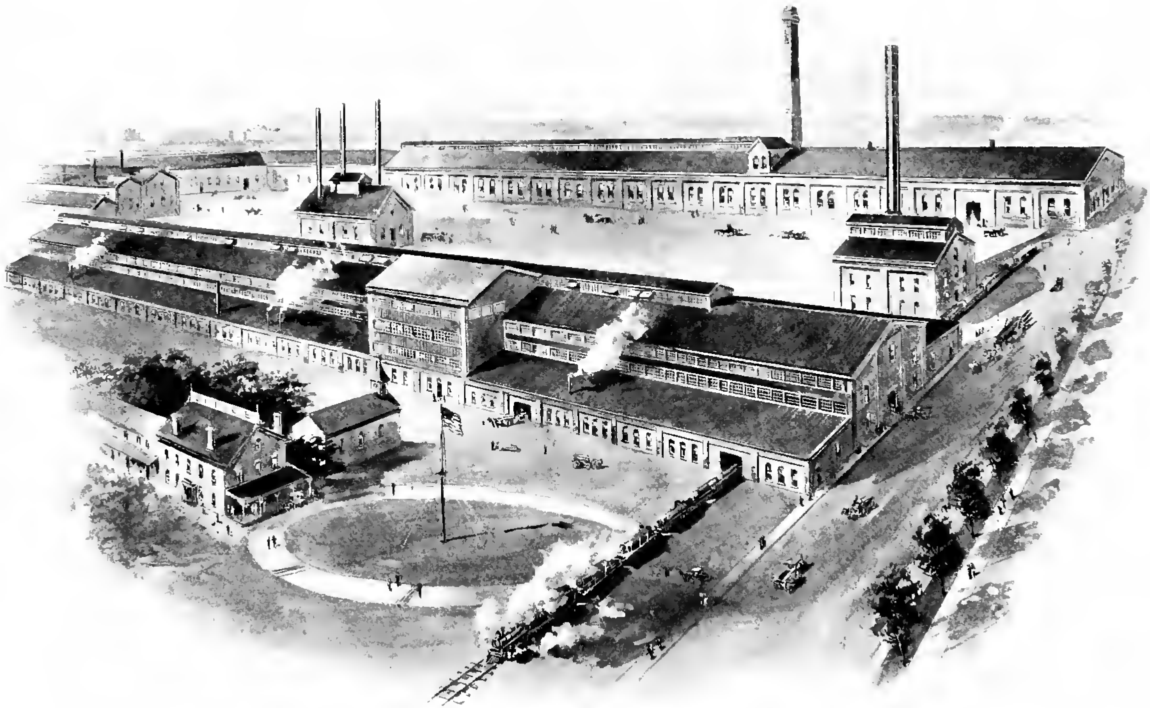


CAHALL FACTORIES
THE AULTMAN & TAYLOR MACHINERY CO., MANSFIELD, OHIO

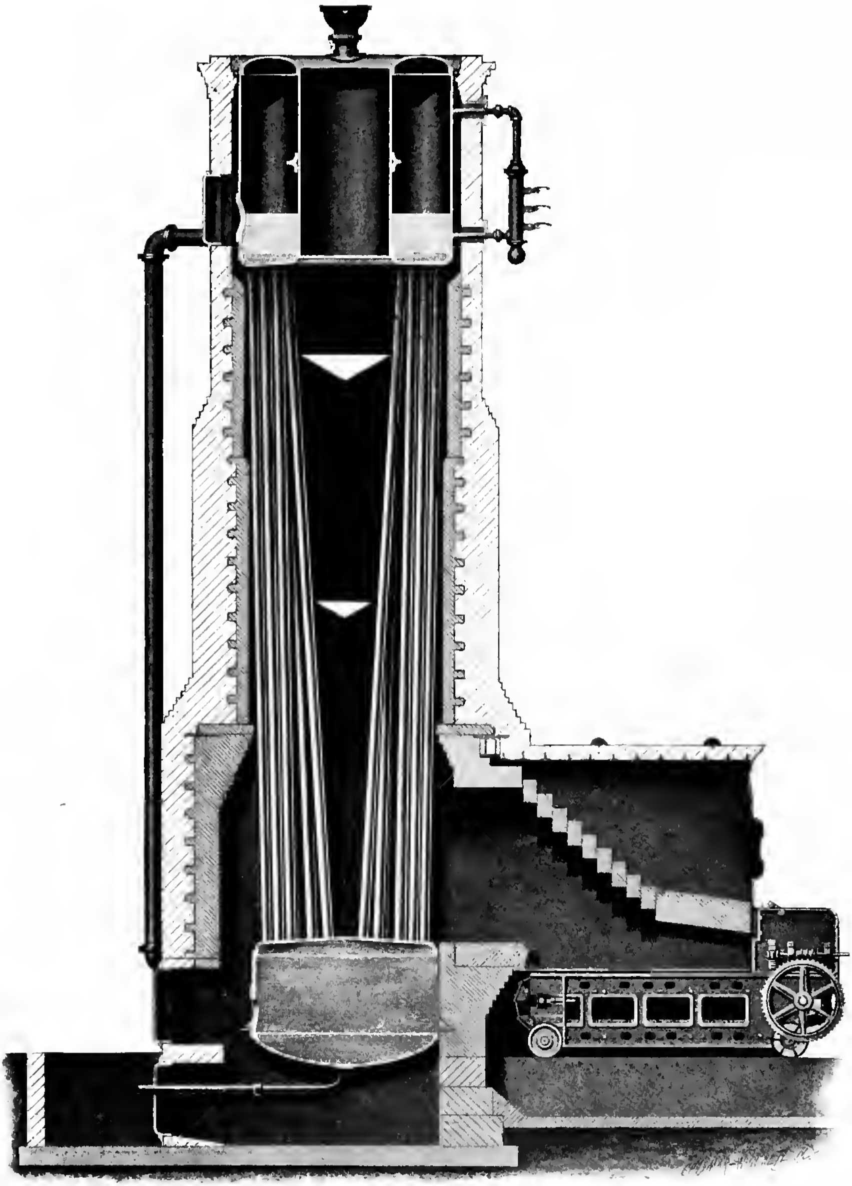
Evolution of Steam Generators

THE steady advance toward perfection can well be exemplified in the generation of steam. Some of the older class of engineers can yet remember the struggle between the old externally fired shell boiler and its then young rival, the multi-tubular. The contest between old-fogyism and advance was bitter, but progress won. Gradually the multi-tubular boiler, with its thin heating surfaces in large areas, demonstrated conclusively its superiority over its cumbersome, extravagant rival, and the shell boiler became a thing of the past. Hardly had the battle been won, when the water tube boiler entered the field to contest with the fire tube the right of existence. In the meantime the same dogged obstinacy that had fought against the introduction of the fire tube boiler transferred its allegiance from the discarded externally fired type to the fire tube type, and the war was waged all over again, and again progress won. For years past, in all high grade power plants, the water tube boiler has been selected as a matter of course. But in this, as in the evolution of the human species, there is no such thing as rest. There is no point where we can stop and say, "Thus far shalt thou go and no farther." The water tube type of boiler hardly becomes the possessor of the field when another struggle occurs and the contest is on between the vertical and the horizontal water tube. Until within the last ten years the horizontal held the field because it *was* a water tube boiler; and a water tube boiler of *any* kind, horizontal or vertical, is so much superior to the fire tube boiler that it naturally survived, being unquestionably the fittest. But experience during the last decade has shown that types of water tube boilers may

INTERIOR VIEW, CAHALL FACTORY

themselves differ from one another in their glory, even as the stars do. The horizontal water tube boiler, although far superior to its predecessor the fire tube, is in its turn being supplanted by the vertical. When the vertical first made its appearance, it in its turn was scoffed at and ridiculed by the fraternity at large, because it was new, different, a strange thing, untried—was looked at as an innovation, and had to fight its way inch by inch into popularity over old-fogyism and prejudice; but the battle is now practically won. The increased circulation, which is positive and unintermittent; the freedom from formation of scale within the tubes in heavy masses, and the freedom from the accumulation of foreign substances outside of the tubes owing to their vertical position; the great capacity and high efficiency shown in repeated comparative tests between the newcomer and its firmly entrenched rival, have given it the preference to-day that the horizontal water tube boiler held fifteen years ago.

The vertical water tube boiler is an unqualified success, and will occupy the field until it in its turn must give way in the future to some new design, even as the others have done in the past. Such is the law of life and progress. It would be interesting to note, if space permitted, the step-by-step evolution of the vertical boiler from the crude experiments in which tubes of distorted shapes and different lengths were used, which, though handicapping the vertical type to a very considerable extent, still demonstrated in no uncertain way that, even in spite of these great mechanical faults, the vertical type as a *type* was superior to the horizontal, even with its perfection of mechanical detail, which had been laboriously evolved through a long period. But inventive genius, never sleeping, eliminated feature by feature these mechanical defects, until to-day the vertical water tube boiler stands perfected, not only in its



CAHALL VERTICAL BOILER WITH CHAIN GRATE STOKER ATTACHED

conception and design, but in its mechanical details, as evidenced by the Cahall Vertical Boiler, manufactured by The Aultman & Taylor Machinery Co., of Mansfield, Ohio.

Test after test has been made on this boiler for efficiency, capacity, durability and safety, and from every trial it has emerged with flying colors, until it would seem that the results obtained left nothing to be desired.

In the matter of capacity it has repeatedly developed, for long periods of time, more than twice the amount of power for which the boiler was designed.

In the point of efficiency it has delivered in dry steam more than 85 per cent. of the theoretical analyzed value of the fuel burned on its grates.

In the matter of freedom from scale accumulation it has run for a period of five years without the introduction of a scraping tool in any of its tubes, and at the end of that time shown heating surfaces as clean as the day the boiler was started, although in the same works, side by side with it, using feed water from the same source, containing the same amount of sediment, horizontal water tube boilers have, within a period of one year from their first steaming, had tubes filled solid with scale.

As to durability in the same plant above mentioned, through this whole period of five years there has never been one penny expended on the boiler proper for repairs from any cause whatever. Such a record may well cause engineers to wonder how it will be possible for a rival to arise that can equal, much less eclipse, a record like this.

TRAIN LOAD OF CAHALL BOILERS AT FACTORY

A Perfect Steam Boiler

The late Mr. George H. Babcock, of Plainfield, N. J., ex-president of the American Society of Mechanical Engineers, was probably a closer student of steam boiler design and construction than any other engineer who has lived during the present century. Shortly before his death he wrote that the result of his engineering experience and scientific investigation for a period of over fifty years in the field of steam boiler practice had established twelve requirements of a *perfect* steam boiler.

That any steam generator should combine every one of these points, all engineers of to-day who have no particular "axe to grind" will readily admit, and we unhesitatingly agree with Mr. Babcock in his deductions.

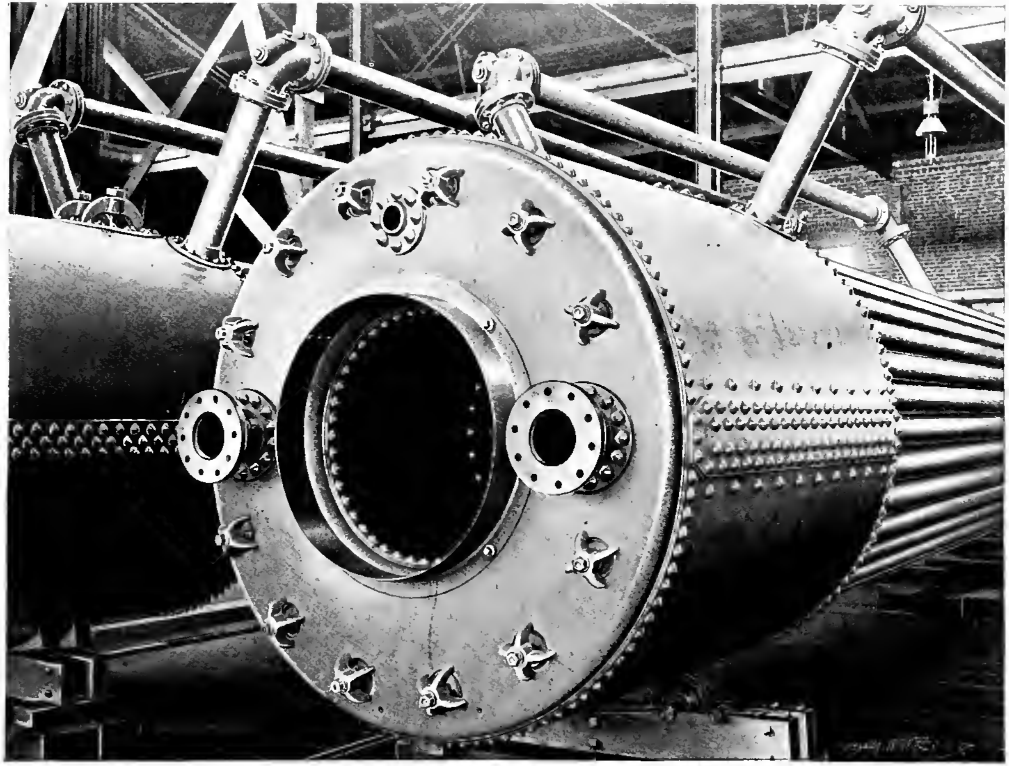
Read carefully these twelve requirements, which are, as stated, the result of over fifty years' hard work, study, research and untiring experiment, and then read the description of the Cahall Vertical Water Tube Boiler which follows, and you cannot fail to be impressed with the wonderful fidelity with which this boiler fulfills every one of these absolute essentials:

Requirements of a Perfect Steam Boiler

1st. The best materials sanctioned by use, simple in construction, perfect in workmanship, durable in use, and not liable to require early repairs.

2d. A mud drum to receive all impurities deposited from the water in a place removed from the action of the fire.

3d. A steam and water capacity sufficient to prevent any fluctuation in pressure or water level.



STEAM DRUM FOR 250 H. P. CAHALL VERTICAL BOILER

4th. A large water surface for the disengagement of the steam from the water in order to prevent foaming.

5th. A constant and thorough circulation of water throughout the boiler, so as to maintain all parts at one temperature.

6th. The water space divided into sections, so arranged that should any section give out, no general explosion can occur, and the destructive effects will be confined to the simple escape of the contents; with large and free passages between the different sections to equalize the water line and pressure in all.

7th. A great excess of strength over any legitimate strain; so constructed as not to be liable to be strained by unequal expansion, and, if possible, no joints exposed to the direct action of the fire.

8th. A combustion chamber, so arranged that the combustion of gases commenced in the furnace may be completed before the escape to the chimney.

9th. The heating surface as nearly as possible at right angles to the currents of heated gases, and so as to break up the currents and extract the entire available heat therefrom.

10th. All parts readily accessible for cleaning and repairs. This is a point of the greatest importance as regards safety and economy.

11th. Proportioned for the work to be done, and capable of working to its full rated capacity with the highest economy.

12th. The very best gauges, safety valves, and other fixtures.

HOMESTEAD, DUQUESNE AND EDGAR THOMPSON WORKS OF THE CARNEGIE STEEL CO., LTD.
USING OVER 60,000 H. P. CAHALL BOILERS.

The Vertical Water Tube Boiler

Manufactured by The Aultman & Taylor Machinery Co., of Mansfield, Ohio, and for which the Cahall Sales Department, Pittsburgh, Pa., are sole agents in the United States, consists of two drums arranged one above the other, made of best mild open hearth flange steel, and connected with four-inch lap-welded best charcoal iron tubes. These tubes are vertical, are perfectly straight throughout their entire length, and are expanded into the drums at each end, making lasting and absolutely tight joints.

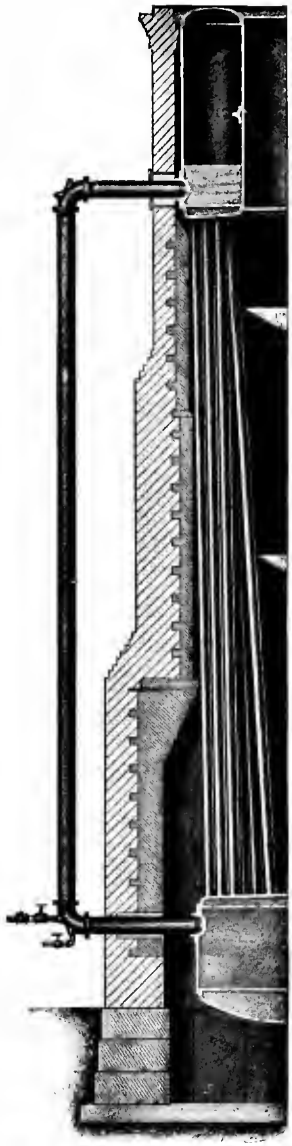
The upper or steam drum has an opening through its center for the exit of waste gases. These gases, although reduced to a very low temperature in passing through the closely grouped tubes of the boiler, will impart most of their retained surplus heat to the metal sides of the passage through this upper drum, thereby tending to slightly superheat the steam in the chamber above. The water line in the upper drum is about two feet above the bottom of the drum, the drum itself being about seven feet high in the clear inside, leaving a space of five feet between the surface of the water and the point at which the steam is drawn off from the boilers, which prevents the carrying over of water with the steam, either in the form of supersaturation or mechanical entrainment.

An external circulating pipe comes out from the upper or steam drum, just below the water level, and is carried downward, outside the brick work, to a point just below the tube sheet of the lower drum, where it enters that drum. There being no steam whatever in this external circulating pipe, and no possibility of making any, and there being, in the tubes connecting

MAIN BOILER HOUSE, APOLLO IRON & STEEL CO.
CONTAINING 10,000 H. P. CAHALL VERTICAL WATER TUBE BOILERS

the two drums, steam in greater or less proportions, the result is (the volume in the external pipe having a considerably greater specific gravity than the mixture of steam and water in the tubes) a very rapid, positive circulation in one direction; the water in the tubes connecting the drums ascending to the steam drum, delivers this mixture of water and steam there, whereupon the steam separates from the water, and after traveling the space of five feet from the water level to the top of the drum, escapes, and the water which is left behind enters the circulating pipe and is carried down to the mud drum and again arises with its mixture of steam.

The boiler rests upon four iron brackets riveted to lower, or mud drum, supported upon four piers of the foundation, the entire structure standing without contact with the brick work, allowing the boiler every freedom for expansion without in any way straining the brick setting. In all places where pipe connections are made to the boilers through the walls, they are encased in expansion boxes.



Circulating Pipes on Cahall Vertical Boiler

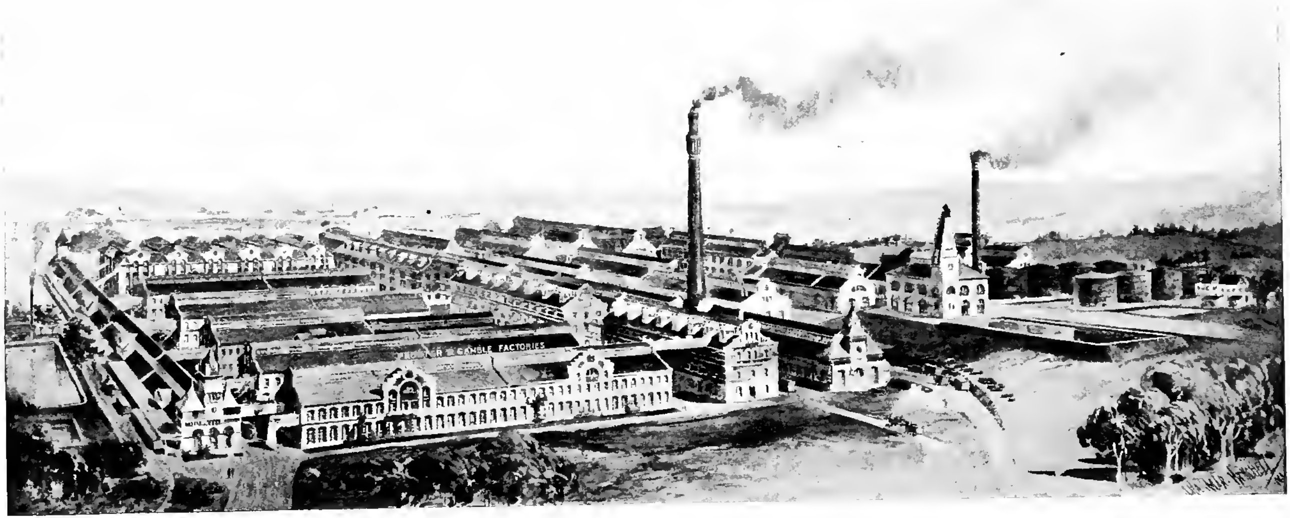
AMERICAN STEEL AND WIRE CO.'S WASHBURNE & MOEN PLANT, WORCESTER, MASS.
USING 3,000 H. P. CAHALL VERTICAL BOILERS

Owing to the fact that the gases escape through the central opening in the upper drum, the upper tube sheet has a circular opening in its center, leaving a central open space between the tubes, which gradually narrows to the bottom tube sheet. Advantage is taken of this space, which is in the form of an inverted cone, to introduce deflecting plates, which in connection with corresponding baffles or offsets in the brick casing cause the gases to be alternately thrown out and in throughout the whole heating surface, which extracts from these gases their heat, until they come to very nearly the temperature of the water contained in the boiler.

As to the actual temperature of escaping gases from this boiler: In a test of 10 hours' duration, made on a direct fired boiler, using bituminous coal, the boiler was run at an average of 30 per cent. above its rating for the entire 10 hours, and the average temperature of escaping gases was 410 degrees Fahrenheit. On another test made on a 150 horse power direct fired boiler, using bituminous coal as fuel, the boiler was forced to 120 per cent. above its rating, delivering 330 horse power, and at no time, even at this phenomenally high rate of evaporation, did the temperature of escaping gases reach 600 degrees Fahrenheit.

This construction presents a form of boiler which, while from its free, direct circulation gives large capacity per square foot of heating surface, at the same time, owing to the direction of the gases over the tubes and the consequent rapid absorption of the heat therefrom, gives an economical performance exceeding that of any boiler in the market.

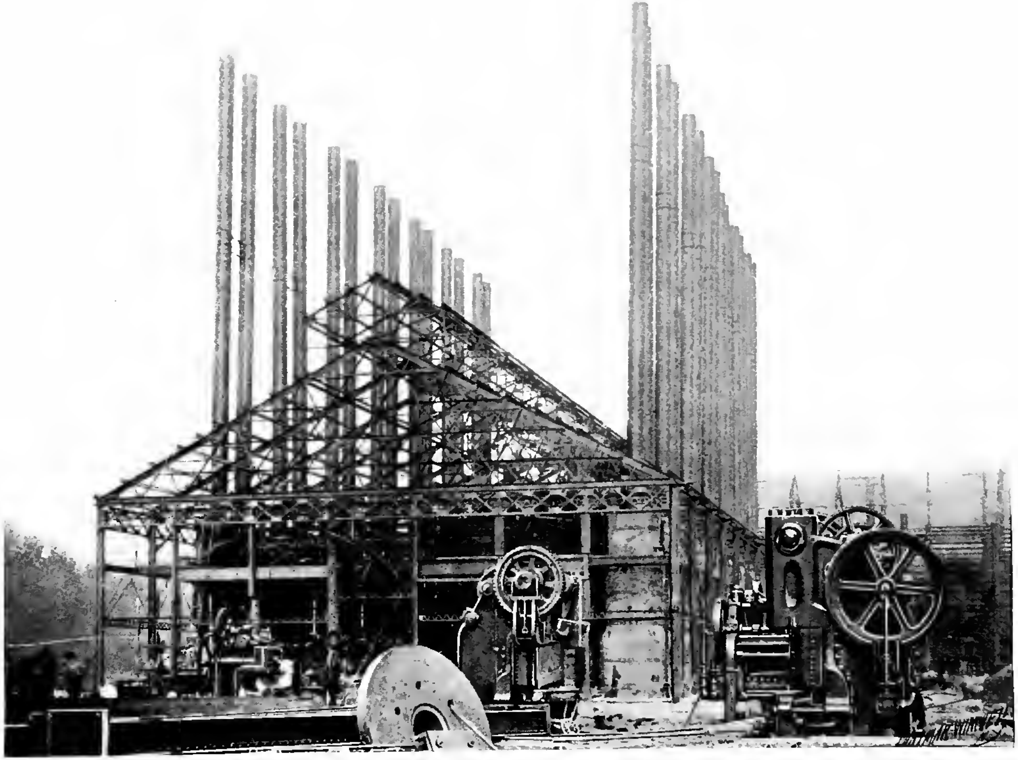
The upper, or steam drum, and the lower, or mud drum of the boilers are equipped with the Cahall patent swinging man-head. By simply taking off the nuts from the man-heads and swinging them open and placing a light in the lower drum, one can from inside the



PLANT OF PROCTOR & GAMBLE, IVORYDALE, OHIO
USING 1,500 H. P. CAHALL VERTICAL WATER TUBE BOILERS

upper drum (which is sufficiently large to admit of a man standing upright and walking around in it) in five minutes examine the condition of every tube in the boiler, and in case scale or sediment is discovered in any of them, can in a few minutes run a scraper through such tubes and render them perfectly clean. The scraper used for cleaning these tubes is made in sections a trifle less than six feet long. Four of these sections are used, and the man who is cleaning the boiler takes them into the upper drum and pushes the first section down as far as it will go, then connects the second section to that, and continues doing this until the scraper has gone entirely through the tube, forcing any scale matter that may have deposited on the sides of the tube straight through to the bottom drum. This form of scraper is very easily handled and takes little time to connect or disconnect, and will thoroughly remove every particle of scale that may form. It will be found in actual practice that the use of the scraper in these boilers will be very seldom necessary, as, for instance, many boilers in use for over five years have never, up to and including the present time, had a cleaner in a single tube.

Right here it might be well to mention that very seldom is a tube in a water tube boiler burnt out on account of a general or uniform deposit of scale on its surface. Most tubes failing are burned because a light scale having accumulated in the tubes, patches of it become loose and fall to the bottom of the tube, and remain there, because the tube lies in an approximately horizontal position. There are many instances where boiler tubes scale uniformly to the thickness of an inch, without any loss from burning. On the other hand, a single patch of scale less than an inch in diameter and one-eighth inch thick, on an otherwise clean tube, frequently causes the tube to burn out at the point

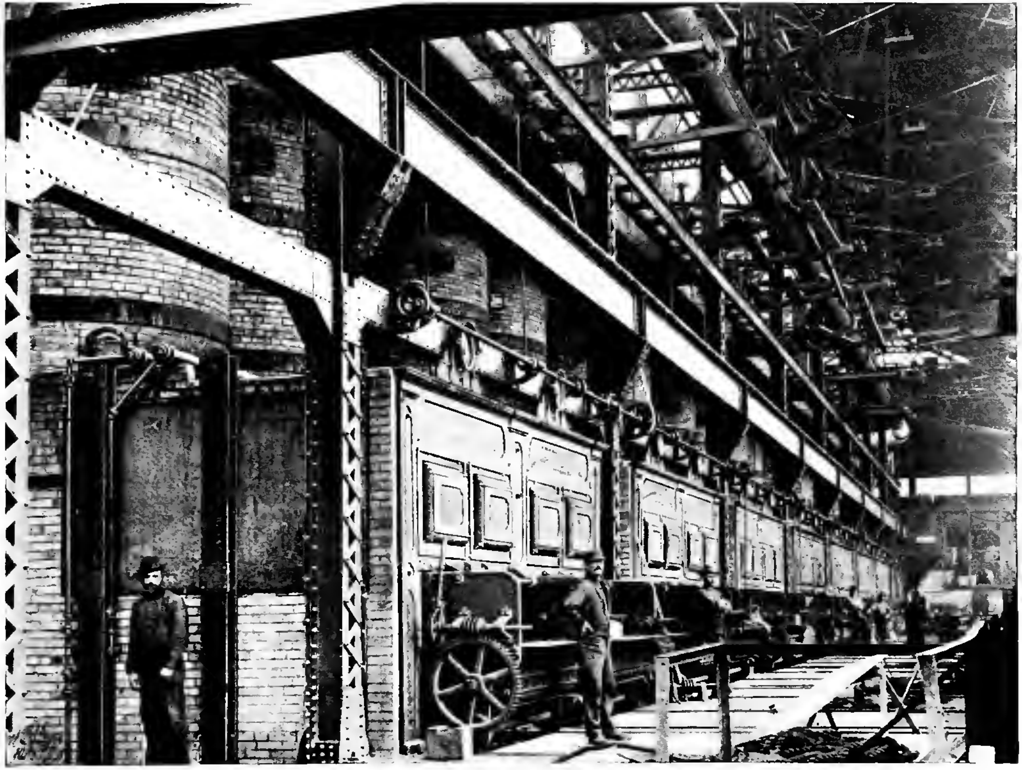


CARNEGIE STEEL CO.'S 128-INCH MILL, HOMESTEAD, PA.
7,000 H. P. CAHALL VERTICAL BOILERS AND CHAIN GRATE STOKERS

where the scale is deposited. It will be seen that, from the arrangement of the tubes in the Cahall boiler, any scale that might loosen will at once fall to the mud drum at the bottom, and, if small enough, will be blown out through the blow-off pipe; if too large for this, it can be removed through the man-hole on regular cleaning day. As the entire lower drum is removed from direct contact with the fire, the presence of scale in this drum can act in no way to the detriment of the boiler, as, the fire not being in contact with the drum, it could not burn, even were the drum allowed to become half filled with scale.

Ample provisions are made for removing defective tubes from the boiler, in the following manner: An examination of the steam-drum cut will show the reader that in the upper or top head of the steam drum there are placed hand holes, which are closed by means of plate, yoke and bolt, in the usual manner; that there are, in addition, other holes used, one for the steam pipe connection, the other for the pop valve connections. By means of these openings a tube needing removal, after having been cut loose from the tube sheets can be pushed up through the tube hole from which it has just been cut and through the most convenient of these openings in the top head, and removed from the boiler. The new tube to replace the defective tube is passed into the boiler through the same openings.

In the waste heat type of boiler the same provisions are made, and in addition, as the whole top of the steam drum is completely covered by the cone-shaped hood forming the base of the smoke stack, there are placed in the sides of the cone, at proper distances, openings, closed by doors, through which the tubes, after having been pushed up through the drum, are taken out and the new ones passed back again, without interfering at all with the stack.



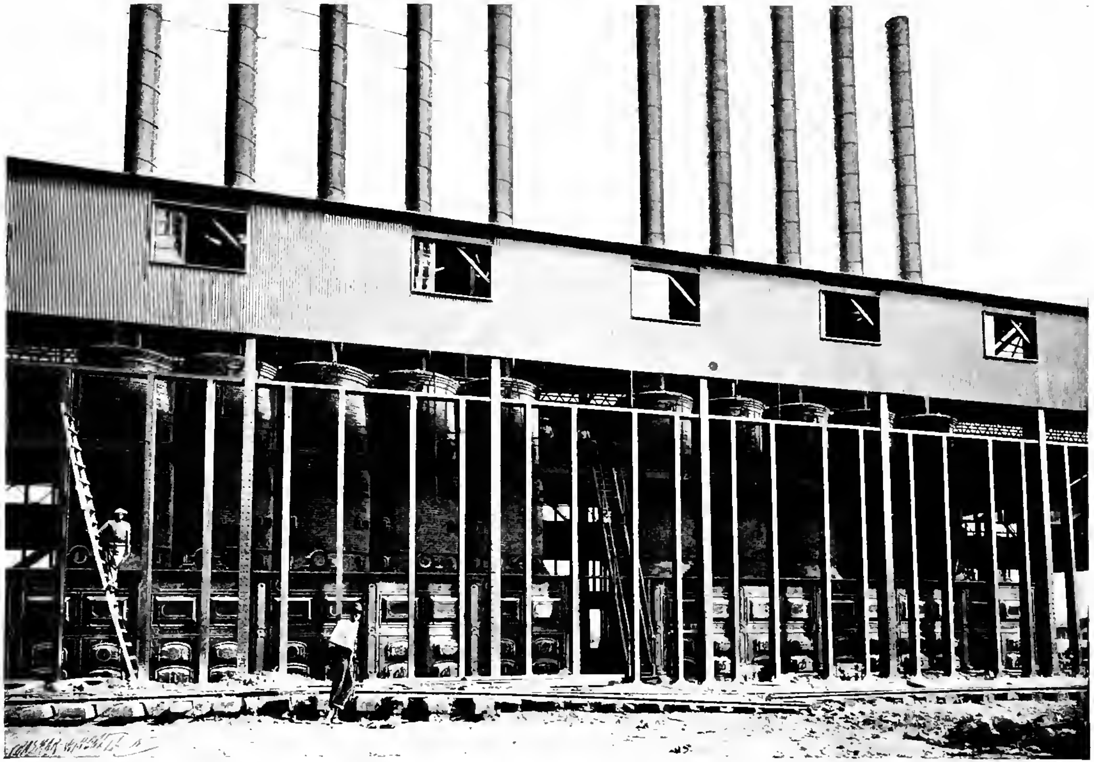
INTERIOR VIEW CARNEGIE STEEL CO., LTD., 48-INCH MILL, HOMESTEAD, PA.
4,000 H. P. CAHALL VERTICAL BOILERS AND CHAIN GRATE STOKERS

All materials furnished in and with this boiler are of the very best; the workmanship is of the highest grade known to the boiler-making art; the safety valves are all of the latest improved pop type, with nickel seats; the fittings and valves are all specially designed, extra heavy, and the best that money can procure.

We are determined to make this the world's standard water tube boiler, and no care or expense will be spared to make it such.

The external combustion chamber, roofed with a heavy fire-brick arch, becomes incandescent shortly after the boiler is fired, and radiates directly on top of the green coal its intense heat, and enables the Cahall boiler to be operated with less smoke than any other boiler can with the ordinary smoke-preventing devices attached. Furthermore, owing to the direct upward passage of all gases, and full, free openings, it can with a comparatively short stack obtain in the furnace a draft pressure that is not possible with most other boilers. For instance, in tests made with a stack only 50 feet high a draft pressure in the furnace of over one-half inch was attained, which is a result that we doubt could be obtained from any other water tube boiler with a stack 100 feet high. This heavy draft causes a very rapid combustion of fuel per square foot of grate, with the consequent high initial temperature of gases which all engineers admit is the primal requisite to efficiency in boiler practice.

To sum up, we furnish a boiler equaled by none built in quality of material, in excellence of workmanship, in surplus capacity per nominal unit, in evaporative efficiency, and in ease of examination and cleaning.

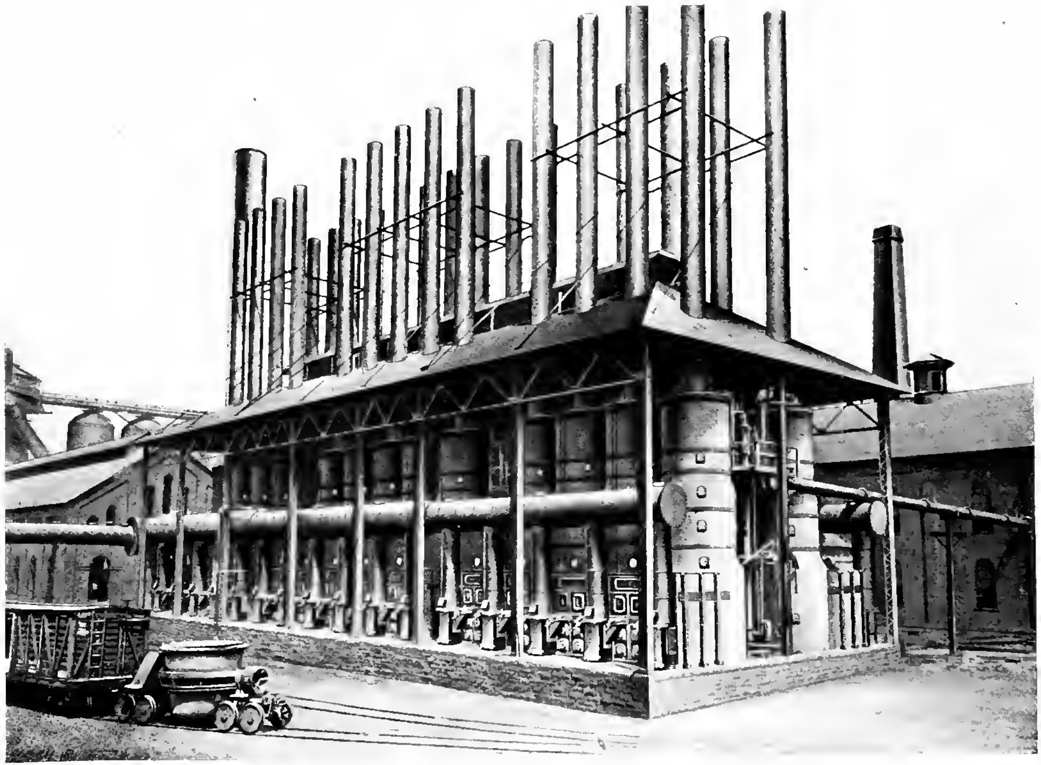


ALABAMA STEEL & SHIPBUILDING CO., BIRMINGHAM, ALA.
BOILER HOUSE CONTAINING 3,000 H. P. CAHALL VERTICAL WATER TUBE BOILERS

Cahall Boilers for Blast Furnace Gases

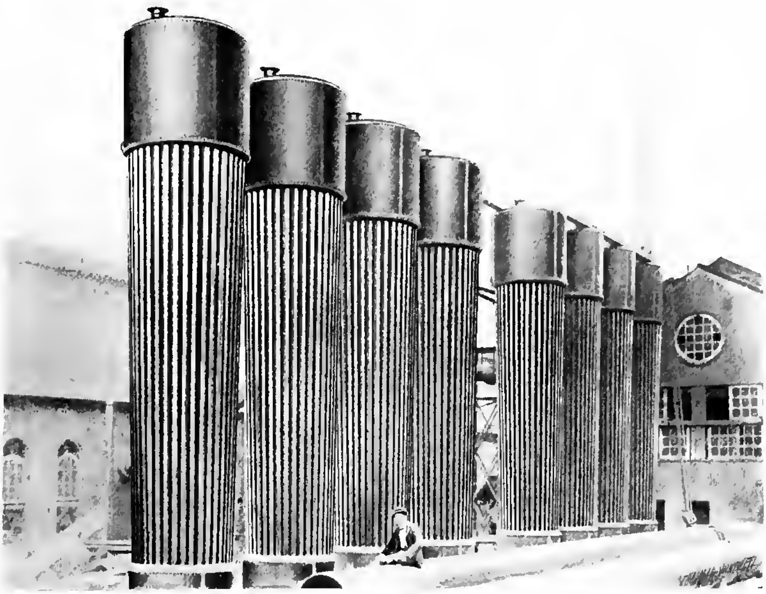
From the foregoing description it is noticeable that this boiler is most admirably adapted for the use of blast furnace gases; the external combustion chamber, imparting as it does its intense heat to the entering gases, puts them in a condition that enables them to take fire instantly and burn freely and quickly. None of the heavy metal sheets of the boiler being in contact with these flames, the intense heat thus generated can have no harmful effect, as it is thrown directly against the very thin metal surfaces of the tubes, the heat from which is readily absorbed by the water contained therein, in the thin columns into which it is subdivided. In tests of boilers using blast furnace gases for fuel, an initial temperature of combustion of over 3,000 degrees has been obtained, and yet the gases are brought so thoroughly in contact with these thin heating surfaces that by the time they reach the opening in the upper drum their temperature is reduced to between 400 and 500 degrees, thus giving an efficiency higher than has ever been obtained by boilers of any type using blast furnace gases as fuel. These highly heated gases, impinging directly on the thin heating surfaces, of course make steam with extreme rapidity, and the heating surface in these boilers being figured more conservatively than in that of any other water tube boiler, allows a great excess over the nominal or rated capacity of the boilers to be taken from them without materially affecting the economy.

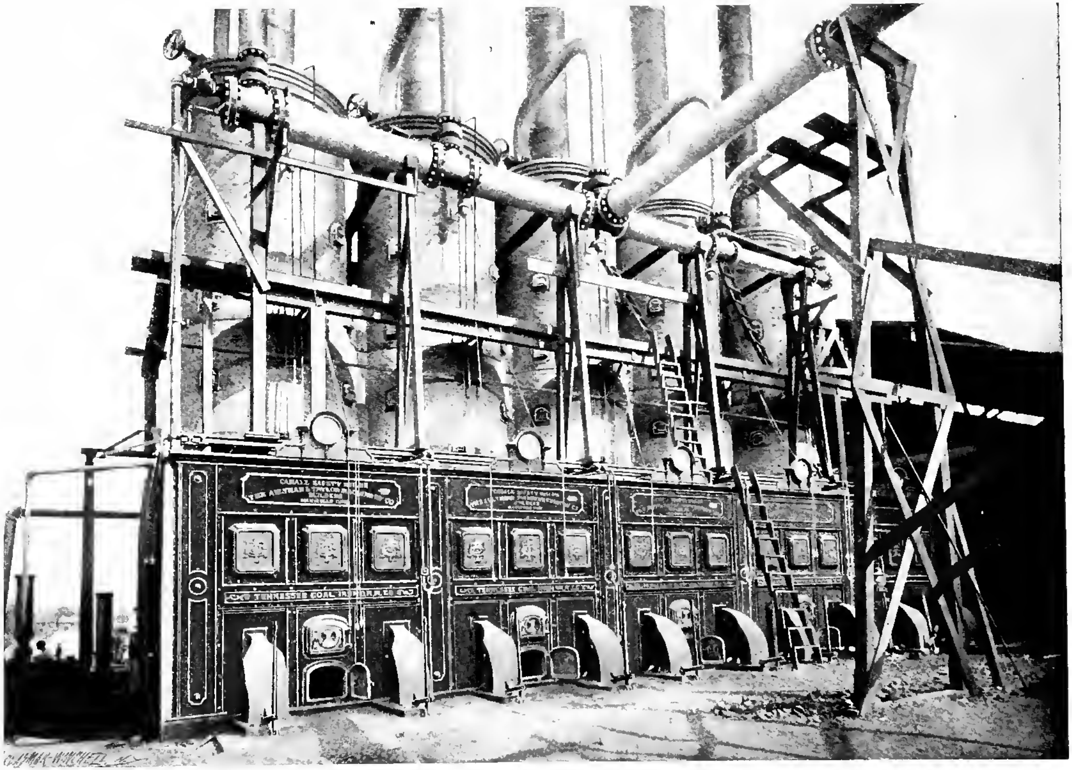
The use of fine ores is becoming more general every year, their low first cost more than counterbalancing the disadvantages which are claimed by some furnacemen



BOILER HOUSE CONTAINING 6,500 H. P. CAHALL VERTICAL WATER TUBE BOILERS
FURNACES D AND E, EDGAR THOMSON WORKS OF THE CARNEGIE STEEL CO., LIMITED

to result from their use. One of the principal among these is the fact that a large quantity of fine ore is carried over with the gases to the boilers. Where boilers with horizontal or approximately horizontal heating surfaces are used, this really becomes a serious drawback, as the ore, together with the other dust always present in furnace gases, piles up so rapidly that it soon stops up all the passages for the heated gases. The Cahall boiler, from its construction, is freed entirely from this trouble, as the surfaces being practically vertical, there is no chance for the accumulation of dirt of any kind on the heating surfaces. It all falls to the bottom part of the boiler, where ample provision is made for readily and easily removing it whenever occasion requires.



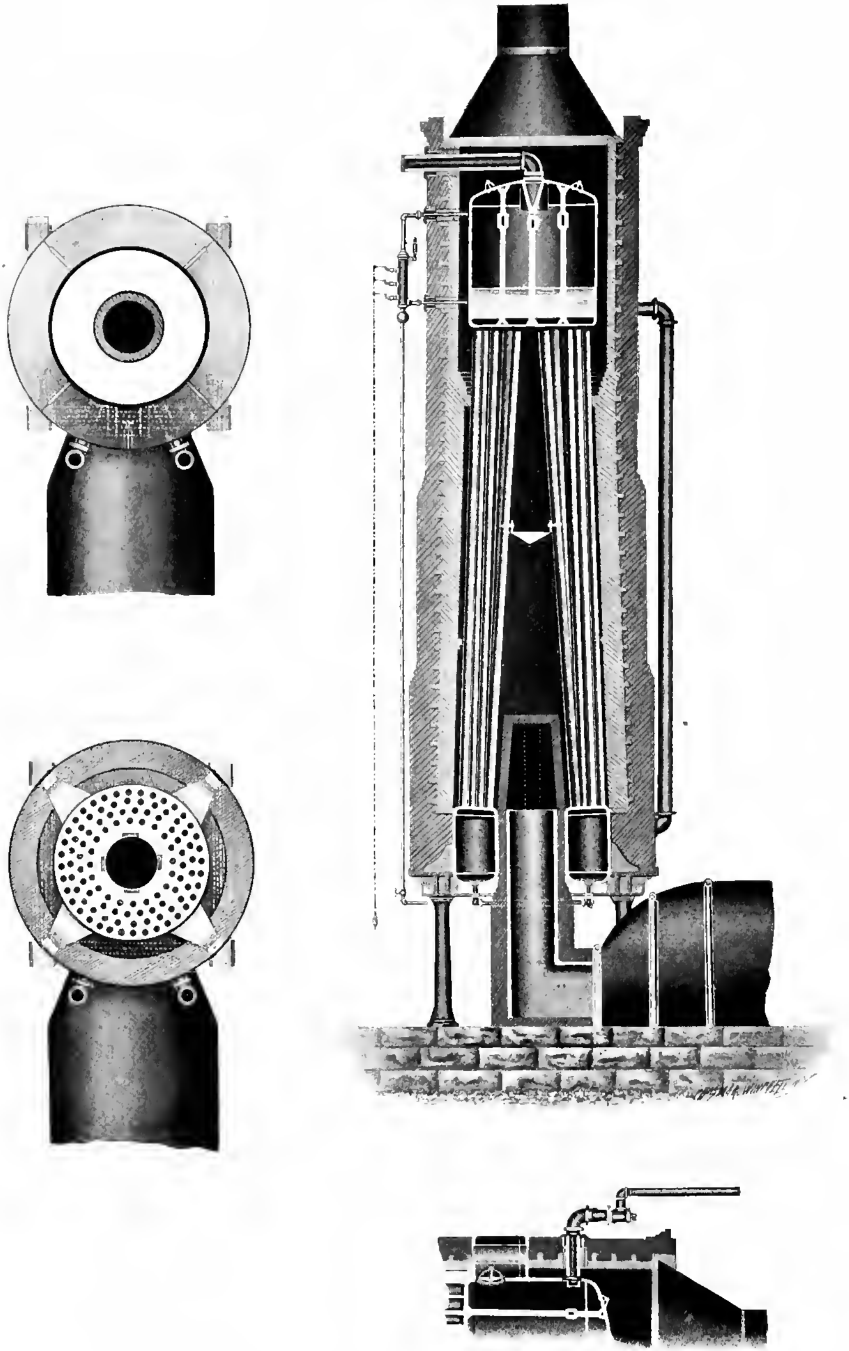


TENNESSEE COAL, IRON & RAILWAY CO., ENSLEY, ALA.
1,500 H. P. CAHALL VERTICAL WATER TUBE BOILERS

Cahall Boilers for Utilizing Waste Heats

For many years it has been a problem, not only in rolling mills but in many other industries, how best to utilize the waste heats from heating or puddling furnaces. In many instances manufacturers have gone to the enormous expense of building elaborate regenerative furnaces of various types, which not only necessitate a very high first cost, but great expense for repairs, which also require considerable time to effect. In any plant where furnaces of any kind for heating or puddling are used, and where there is any steam power required, the ideal method for utilizing the heat from these gases is to make steam with it.

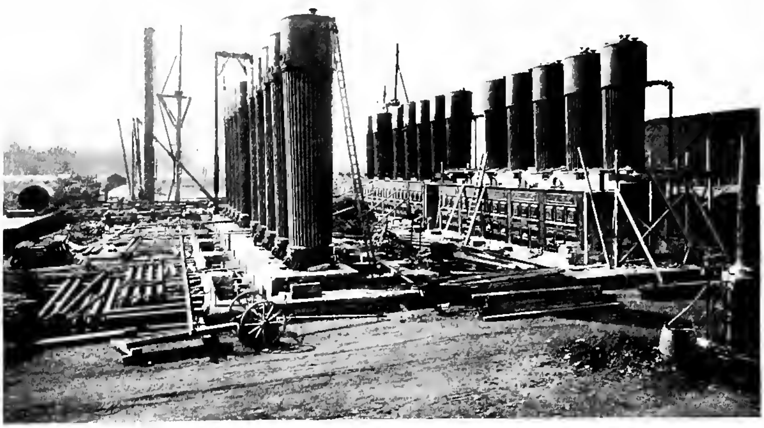
We have a special design of boiler (cuts of which are shown) intended solely for the purpose of utilizing these waste heats. It is much cheaper to build a good reverberatory furnace and attach a boiler thereto, than it is to build a first-class regenerative furnace, and in most plants, especially in the iron and steel industry, sufficient steam power can be generated from waste heats to run the entire works, thereby not only saving the cost of the fuel now being burned under existing boilers, but saving the room occupied by those boilers and the wages of the firemen necessary to handle the coal and ashes. In general practice, the waste heat boiler applied over a heating or puddling furnace will deliver a horse power for each five pounds of coal fired in the furnace per hour, and with coal at $1 a ton, a horse power of steam costs, with boilers direct fired, about $25 per annum. A heating furnace, therefore, consuming the equivalent of 600 pounds of coal an hour, will deliver steam from its waste heats aggregating 120



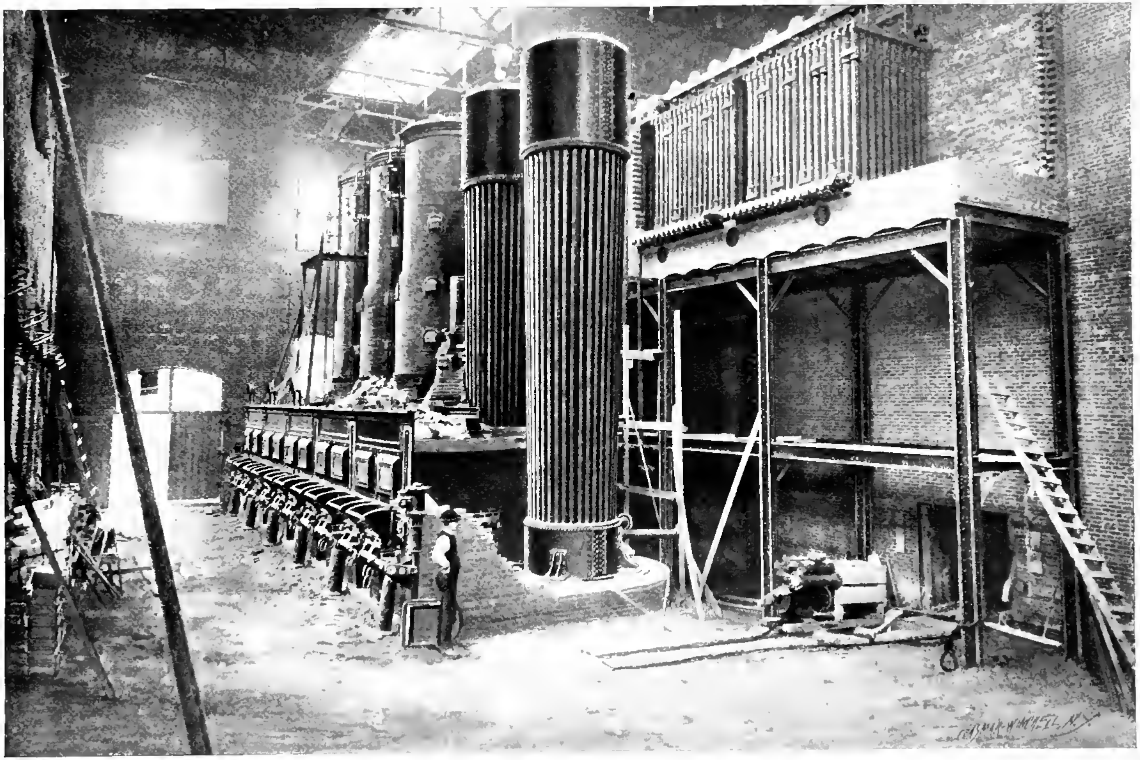
CAHALL VERTICAL BOILER FOR WASTE HEATS

horse power, or a money value of about $3,000 per year, with coal at $1 per ton, delivered.

This amount of saving will, each year, more than pay the entire cost of the boiler plant complete, ready for steam; in fact, in the Pittsburgh district, where coal can be procured at the very low price of sixty cents per ton, delivered, we have several plants of these waste heat boilers running on which the saving on coal alone pays an annual dividend of from 115 to 140 per cent. on the first cost of the boiler plant complete. This is a very important subject, and one that requires careful consideration on the part of manufacturers having places wherein to make installations of this kind, and we would like very much to open correspondence and furnish drawings and estimates for installing these waste heat boilers in places where it is possible.



FEDERAL STEEL CO.'S LORAIN BLAST FURNACES, LORAIN, OHIO
6,000 H. P. CAHALL VERTICAL BOILERS



LANCASTER MILLS, CLINTON, MASS. 1,250 H. P. CAHALL VERTICAL WATER TUBE BOILERS

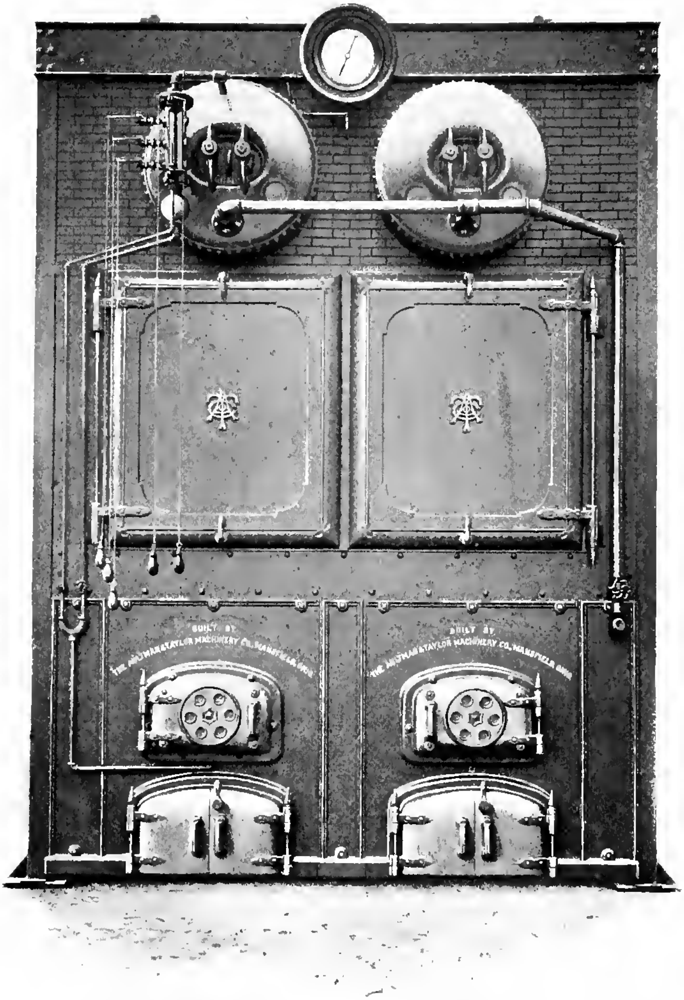
Cahall Horizontal Boilers

The illustrations given show the horizontal type of boiler manufactured by the Aultman & Taylor Machinery Co., of Mansfield, Ohio. Some time ago, finding that there were many locations where it was impossible, on account of lack of space, to install a vertical boiler, the Aultman & Taylor Machinery Co. decided to build a horizontal water tube boiler in addition to their vertical. After thorough investigation they decided that the sectional header type had shown the best results of any of the horizontal water tube boilers in the market, and they therefore adopted this type for their horizontal boiler.

These boilers are built in sizes of from 125 horse power up to 850 horse power in single units. They also build what is known as the "double-decker" type of this same boiler. The boilers are built for working pressures of from 160 pounds to the square inch up to 500 pounds to the square inch.

The factories of the Aultman & Taylor Machinery Co., at Mansfield, Ohio, are ample in size, are new, and equipped with the very latest tools and machinery. With the exception of the hydraulic and pneumatic plant, all the tools in the factory are direct electrically driven. The factory has an annual capacity of 400,000 horse power of Cahall Vertical Boilers and 200,000 horse power of Cahall Horizontal Boilers with the present facilities.

Going into specific detail as to the manufacture of these boilers, we will begin with the steam drums. These are made of best open hearth flange steel, the heads for the drums being of the same material, hydraulically flanged. All the sheets are beveled on



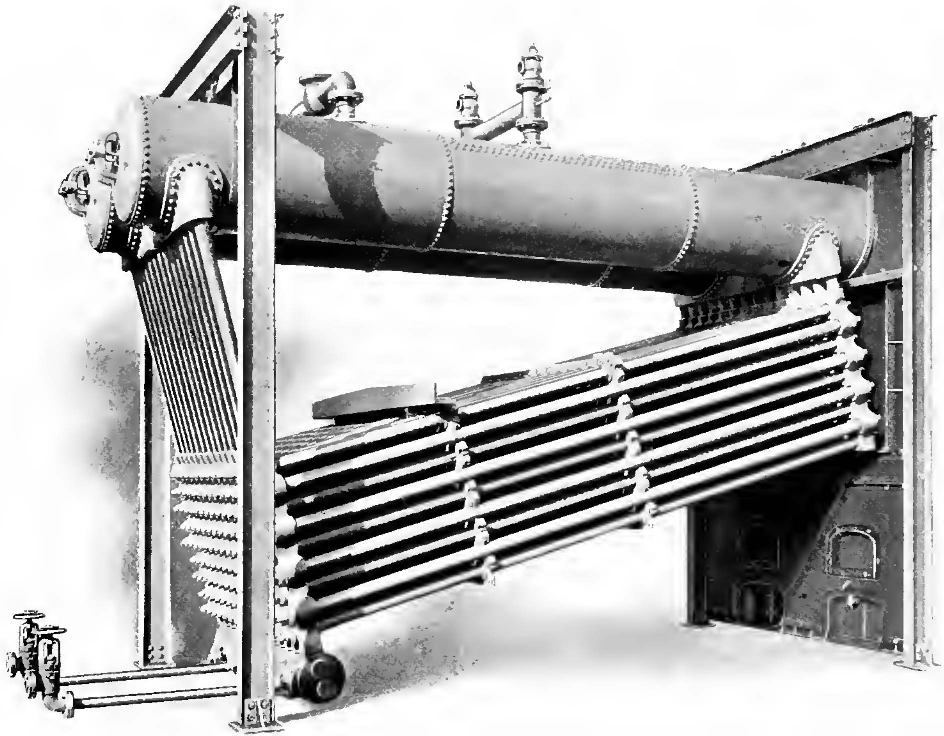
FRONT VIEW OF 250 H. P. CAHALL HORIZONTAL BOILER

the edges, bent into shape, and the rivet holes drilled after bending. This insures absolutely round holes without crystallization and allows calking of all seams, both inside and out. In boilers the working pressure of which is not to exceed 160 pounds to the square inch, the longitudinal seams in the drums are double riveted. In the higher pressure boilers, that is, from 160 up to 500 pounds, all horizontal seams are butt and double strapped joints with six rows of rivets. This makes the very finest possible joint, and when made with the care that is always exercised in our factories, is really a piece of fine art in boiler manufacture.

Each drum is provided at both ends with the Cahall patent swinging man-head. This device, although very simple, is something of great importance. Engineers who have been annoyed with the laborious and tedious practice of taking man-heads out of boilers and lifting their heavy weight to a place of security, and then going through the annoyance of putting them back in their places again after the work in the boiler is finished, will appreciate fully the device which is furnished with these boilers. By simply loosening the nuts on this man-head, a slight push swings the head in as though it were a door, and it fits back in place against the drum, without occupying any appreciable amount of room, and when the time arrives to again close it, it is pulled back to its place Being hinged, as it is, the seats come together in exactly the same place every time, and the joint being made tight once is tight for all time, less than one minute being required to open the man-head and close it perfectly tight.

The flanges on the steam drums for the steam and safety valve openings are all drop forged, from flanged steel plates.

It will be noticed from the rear view of the boiler in the accompanying illustration, that each section of



SIDE VIEW OF 250 H. P. CAHALL HORIZONTAL BOILER
SUSPENDED READY FOR BRICK WORK

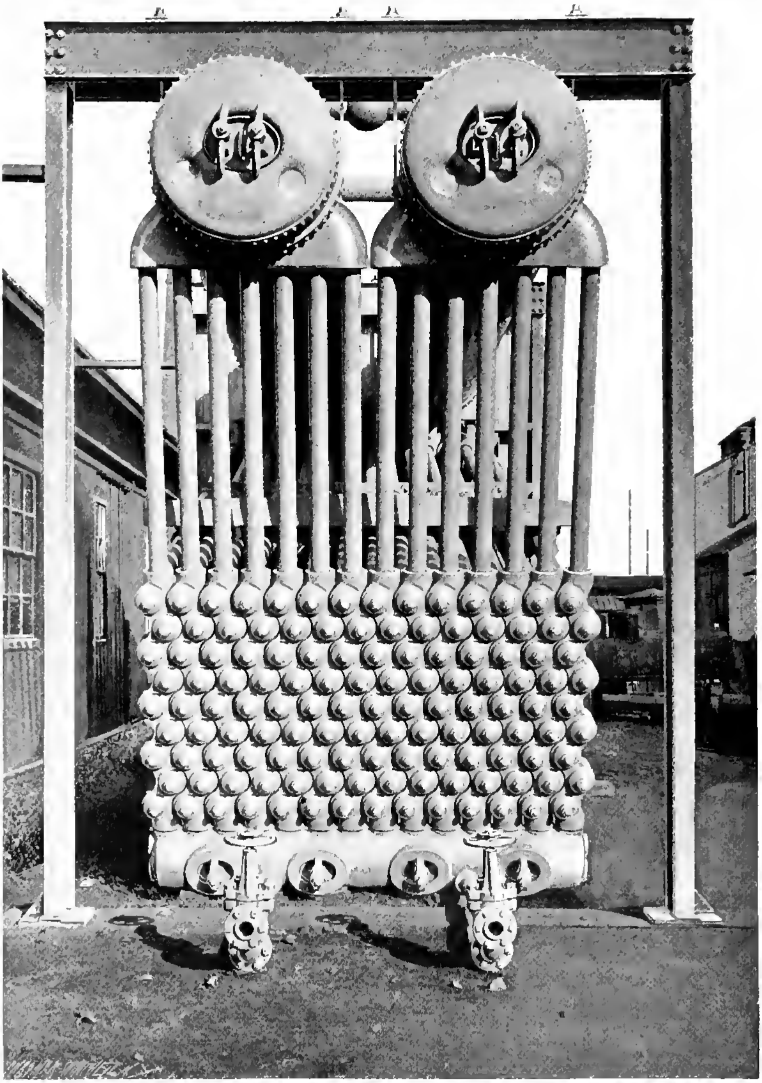
tubes is connected by nipples to cross-boxes, or saddles, on the steam drums. In all other boilers of this type made at the present time, these cross-boxes are manufactured either of flanged steel plates or cast iron. Both of these are improper. If made of cast iron, it is impossible to have the curvature of the box conform exactly to the curvature of the drum, and when they are riveted in place either one of three things must occur: (1) The sheets in the drums are distorted, (2) the cast iron is cracked from the pressure, or (3) a leaky joint is made. The leaky joint is the most frequent result. When the manufacturers find this they generally attempt to calk up the space with various metals, lead or babbitt metal having been used in many cases, with the result that might be expected. After the boilers have been tested and accepted, the metal melts out and serious and irreparable leaks develop. The flanged cross-boxes are wrong for the reason that they are made of a flat sheet, which through successive heatings and applications of hydraulic pressure is bent around sharp corners, resulting in a great pull or strain or stretch on these corners, which frequently reduces the thickness of the metal in places to the danger point. Moreover, at the ends of the cross-boxes, where the outside nipples go in, the recess inside the cross-box is so shallow that it is impossible to remove a nipple after the boilers are once erected without tearing down a portion of the brick work to do it. In the Cahall Horizontal Boiler these cross-boxes are made from open hearth steel, which is melted and run into molds, making what we have termed "flowed" steel. This steel, after cooling and annealing, presents all the chemical and physical properties of regular boiler plate steel, physical tests on a large number of coupons from these forms showing an elongation of over 25 per cent., a reduction in area of over 50 per cent., with a tensile strength of over 60,000

SIDE VIEW 250 H. P. CAHALL HORIZONTAL "VERTICAL HEADER" BOILER

pounds to the square inch. Manufacturing the cross-boxes under this process allows any thickness of metal desired at all points in the cross-box where it is most desirable, and, moreover, permits making sufficient depth in the cross-box to make renewals or repairs of connecting nipples without interfering with any other portion of the boiler. This is a feature that is bound to become recognized as one of great value within a few years, when the troubles that are certain to arise from the use of forged steel cross-boxes and headers become more generally known.

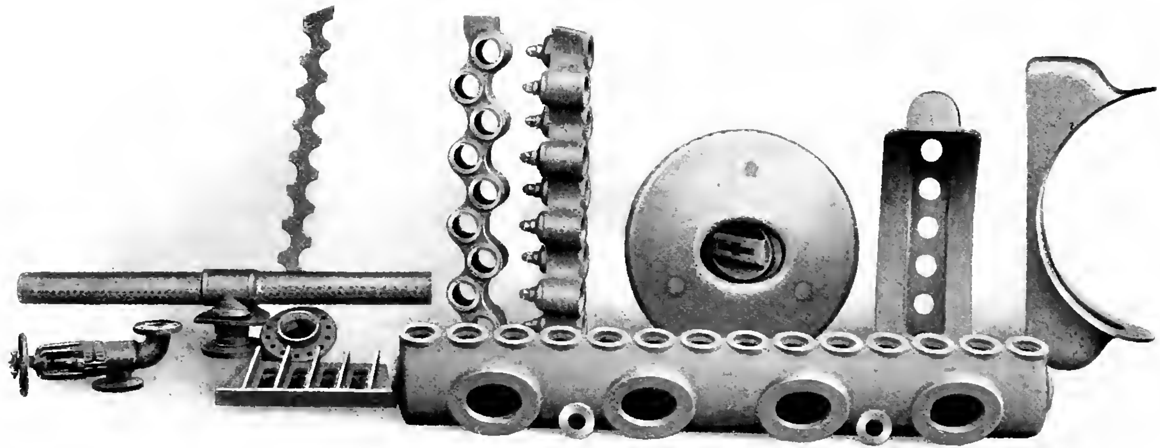
The steam drums in their entirety are made of the very best of materials, and the workmanship is exact, everything being done to templates, and all parts fitting to a hair's breadth before the drums are even tested.

As will be seen from the illustrations, the headers or manifolds into which the tubes are expanded are of the standard sinuous type. These headers are made of a special mix of cast iron. The Aultman & Taylor Machinery Co. have been building steam engines and other machinery requiring very intricate and delicate castings for nearly thirty years, and have a most thorough knowledge of the best mixes of iron to accomplish given results. To secure the best effects with these headers the mix must be a tough, close-grained iron, and the mix that we use for this purpose shows a tensile strength nearly 25 per cent. higher than that used heretofore in the manufacture of headers of this type, as shown by actual hydraulic stress applied in numerous instances. We also make these headers about 25 pounds heavier that has been customary with other manufacturers of these boilers in the past, and distribute this additional weight almost entirely in the form of fillets where sharp corners have heretofore been allowed. There are no sharp corners permitted in the headers of our manufacture, every corner being filled out to a



REAR VIEW OF 250 H. P. CAHALL HORIZONTAL BOILER
SUSPENDED READY FOR BRICK WORK

perfect curve by the use of these fillets. The result is, that while cast iron headers as heretofore made will break at an applied pressure of from 1,400 to 1,600 pounds to the square inch in nearly all cases, we repeatedly subject those made at our works to a pressure of 2,000 pounds to the square inch without any sign of rupture. The holes in these headers for the reception of the tubes, and into which the tubes are expanded, have in other makes of sectional header boilers been generally left rough as they come from the sand. As it is impossible to get a perfect seat in this way, leaky joints have been very frequent. We have designed a special tool for reaming all these holes to an absolutely perfect seat, preventing the possibility of this leakage ever occurring. The seats on the opposite side of the manifold covered by the hand-hole caps, for access to the tubes after the boiler is erected, are cut down and milled to a perfect face and the caps which fit over these are also milled and smooth finished, so that when they are put in position they make a steam and water tight joint without the intervention of packing of any kind. The hand-hole guards which go inside these hand-hole plates, to which the bolt for fastening the hand-hole plates in position is fastened, are made of drop-forged steel and are elliptical in form, so that they cover almost entirely the inside of the hand-hole. This is done as a safeguard, so that in case a bolt fastening the hand-hole plate in position should break from any cause, there can be no sudden rush of steam or water through the hand-hole, which has frequently occurred with considerable damage to men and property. The bolts used for fastening these hand-hole caps in place are of the very best iron, 1⅛ inches in thickness. It can be seen from the side view of the boiler that it stands on wrought iron supports and cross beams, independent of the brickwork, so that the entire structure is free to contract and expand without



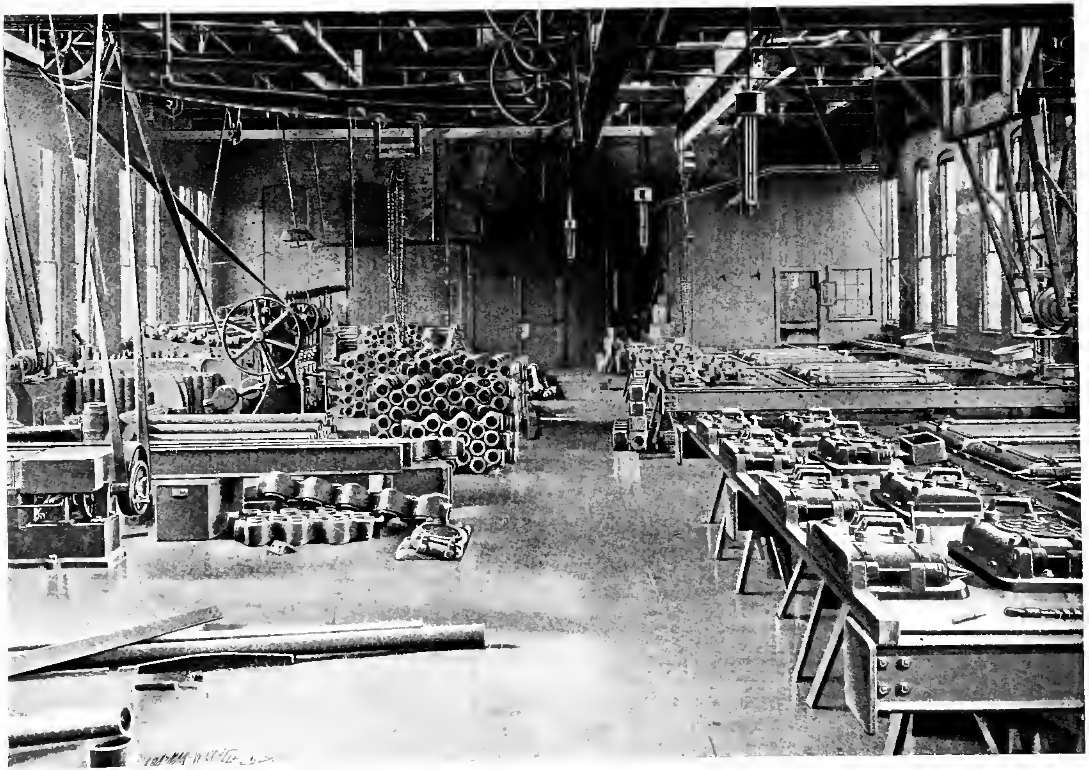
CROSS BOXES, HEADERS, MUD DRUM AND MINOR PARTS OF CAHALL HORIZONTAL BOILERS

any strains occurring either on the setting or on the boiler itself. In our method of suspension, we have our entire framework outside of the brickwork, thereby avoiding the possibility of its burning away or weakening through overheating, as has frequently happened in the case of other makes.

The fronts for the boiler are what is known as the wrought iron style—that is, the entire general framework of the front is made up of wrought iron or steel beams, channels and girders, and only the panels containing the door frames are cast. This permits of a very light but rigid structure, which it is impossible to crack from the application of internal heat, which has been heretofore one of the greatest faults found with this type of boiler.

All the tubes used in this boiler are made of the best knobbled charcoal iron, which though very much more expensive than the standard iron boiler tube, yet repays the customer in future years for the additional investment in first cost. The general fittings and trimmings of the boiler are of the highest grade purchasable, the safety valves being of the solid nickel seated type. The water column used is either the Reliance or Pittsburgh High and Low Water Alarm. The blow-off valves are specially made under patents owned by the Aultman & Taylor Machinery Co., and are so designed that the discs are renewable at any time and both the disc and valve seat can be cleaned without taking the valve apart.

It will be noticed in the illustration giving the rear view of the boiler that these valves have two wheels, one directly above the other, the upper one being smaller than the lower. The larger wheel forces the disc down on its seat, the smaller wheel revolves the spindle carrying the disc. By revolving the larger wheel until the disc rests lightly on its seat and then revolving the smaller wheel, the disc is rotated on its

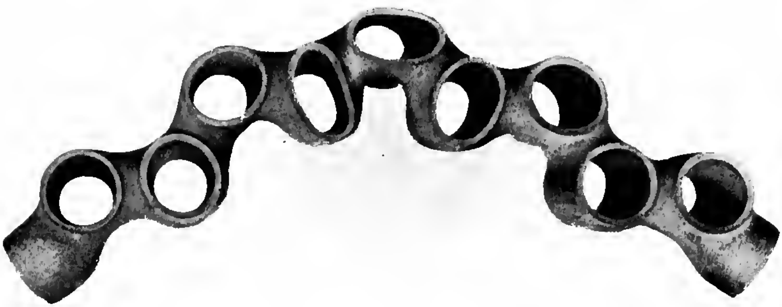


ASSEMBLING ROOM FOR CAHALL HORIZONTAL BOILER SECTIONS AND FRONTS

seat, effectually clearing it of any obstructions that may have accumulated thereon.

The side cleaning doors for the boiler are of a new design, which permits the use of only one door instead of two, and when the door is opened it is thrown back entirely from the slot into which it fits, leaving a full, free opening for the introduction of the steam hose, and when the door is closed wedge-shaped fire-brick tile, which line the door, are pushed forward in a straight line into the opening, making a perfectly smooth wall on the inside and an absolutely tight joint against the leakage of air into the setting.

Where very high pressures are to be used, say in excess of 225 pounds to the square inch, the headers or manifolds for the reception of the tubes are made of the same material used in the cross-boxes on the drums, viz., special "flowed" steel.



CAHALL "FLOWED" STEEL HEADER

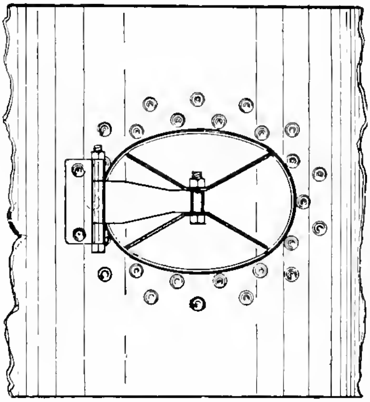
This header was subjected to the following tests: Thirty blows with 60 pound sledge hammer; six blows under steam hammer delivering blow of about 2,000 pounds; was then bent into present shape *cold* by water pressure.

MANIFOLD OR HEADER WITH HAND HOLE CAP, SAFETY GUARD, BOLT AND NUT, AS USED WITH CAHALL HORIZONTAL BOILERS

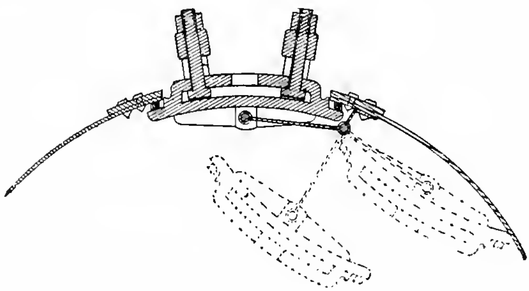
Cahall Swinging Man-head

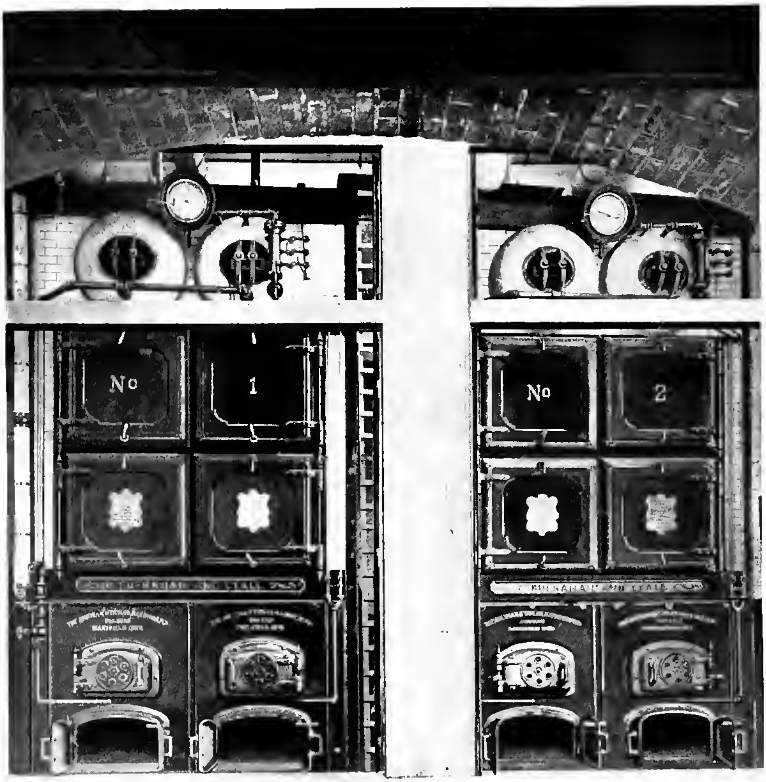
(Patented)

The patent man-head used on Cahall boiler drums, while a very simple device, yet is something of great importance. Engineers who for years have been



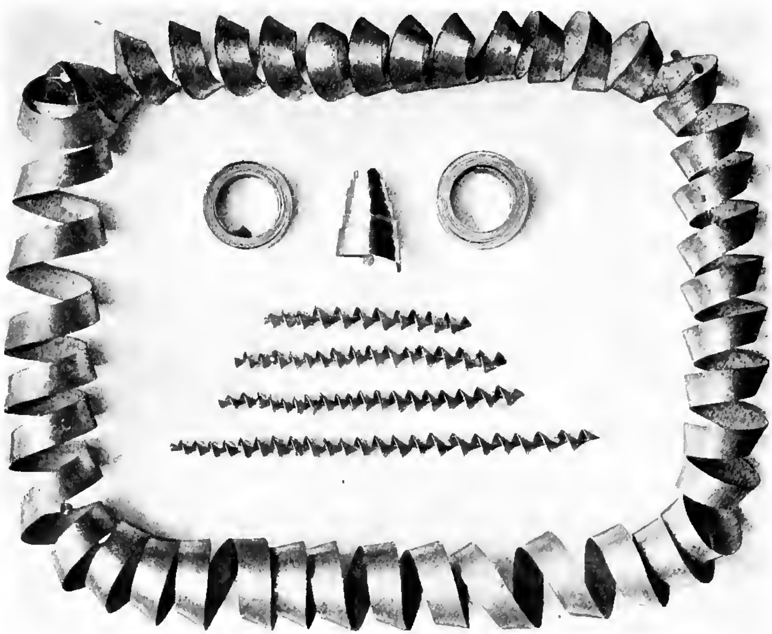
annoyed with the laborious and tedious practice of taking man-heads out of boilers and lifting their heavy weight to a place of safety, and then putting them back into



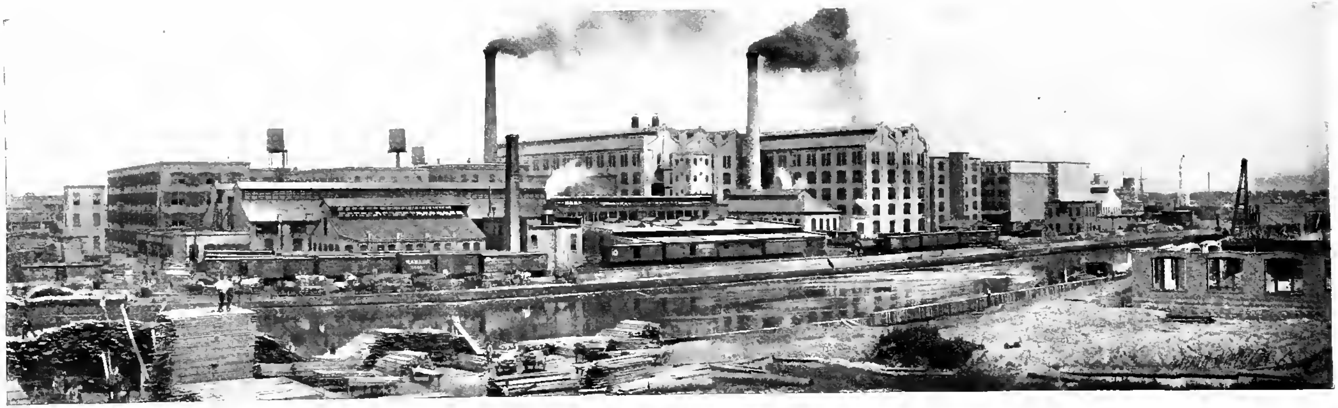


BUCHANAN & LYALL, BROOKLYN, N. Y.
500 H. P. CAHALL HORIZONTAL BOILERS

their places again after the work in the boiler is finished, will appreciate fully the device which is shown in the cuts on page 47. By simply loosening the nuts on this man-head, a slight push swings the head in as though it were a door, and it fits back in place against the drum without occupying any appreciable amount of room, and when the time arrives to again close it, it is pulled back to its place. Being hinged, the seats come together in exactly the same place every time, and the joint being made tight once is tight for all time; less than one minute is required to open the man-head and close it again perfectly tight.



BORINGS AND TURNINGS FROM "FLOWED" STEEL



McCORMICK HARVESTING MACHINE CO.'S WORKS, CHICAGO
USING 8,658 H. P. CAHALL HORIZONTAL BOILERS AND CHAIN GRATE STOKERS

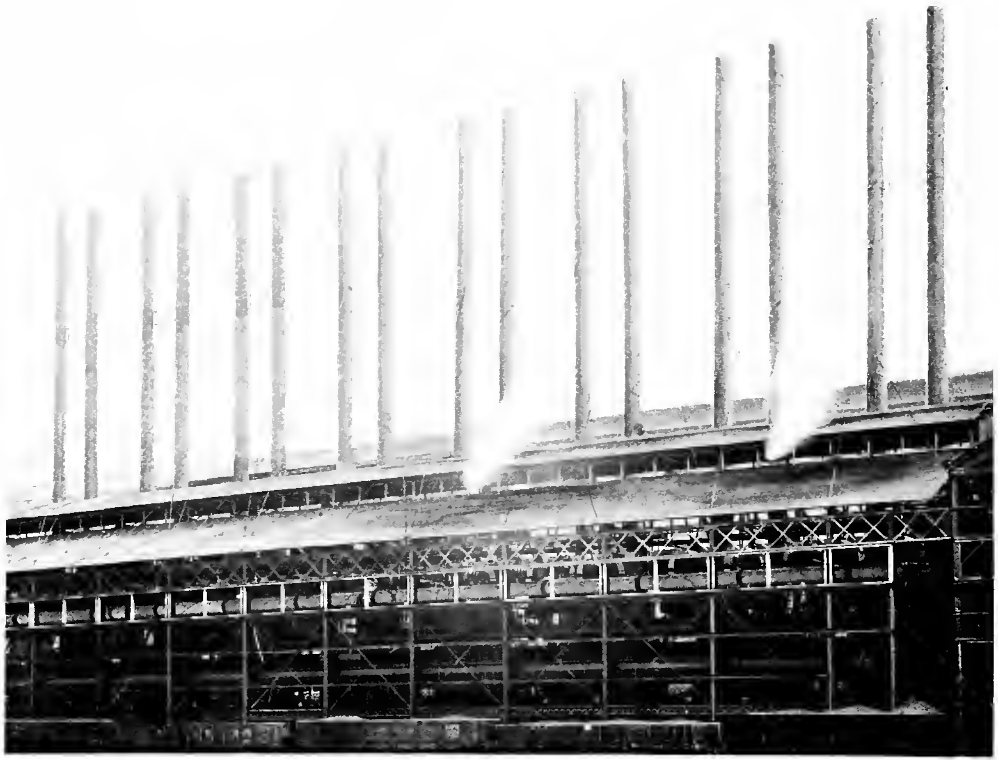
Mansfield Chain Grate Stoker

On pages 53 and 57 we give cuts of our Mansfield Chain Grate Stoker. The stoker consists, as shown in the illustrations, of a series of links bound together in an endless chain, which is driven by a sprocket wheel, this in turn being driven by a small engine connected to the line shafting. The simple construction of the device makes it practically free from repairs, but in cases where repairs are necessary, the fact that the stoker can be withdrawn entirely from underneath the boiler, leaving all parts accessible, renders it a simple matter to renew links should any happen to burn out.

We have installed during the year 1899 approximately 50,000 horse power of these chain grate stokers, all of which are giving entire satisfaction, and we have yet to hear of the first word of complaint concerning them.

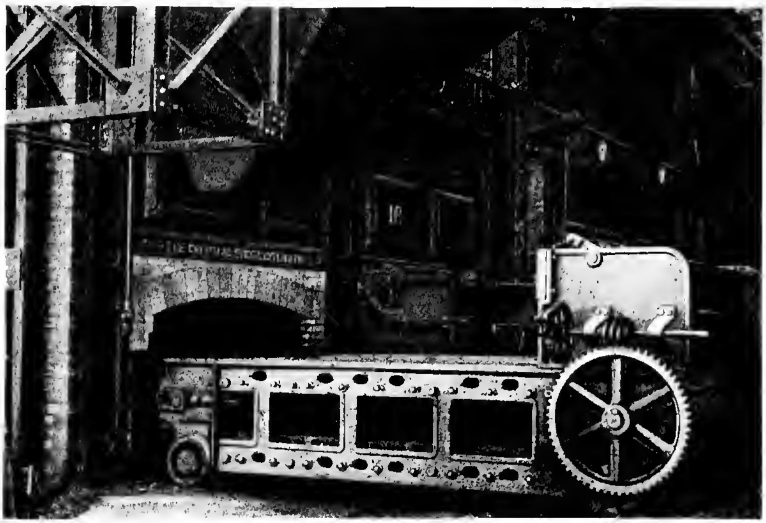
An interesting cut is shown on page 52. This cut shows a battery of sixteen Cahall Vertical Boilers equipped with Mansfield Chain Grate Stokers. Eight of these boilers, at the time the photograph was taken, were in full operation and the balance were not running, showing the device to be "absolutely smokeless." Note it is impossible to tell which eight boilers are not in operation and which eight are; the only way that it is possible to detect which are running is, as the reader will observe, that in the cut referred to the eight boilers on the right-hand side show the exhaust steam from the two engines that are driving the stokers under those boilers. There was no trace of smoke from the stacks by which to determine what boilers were in operation.

In addition to its advantage in being smokeless, the chain grate stoker will show a greater efficiency over

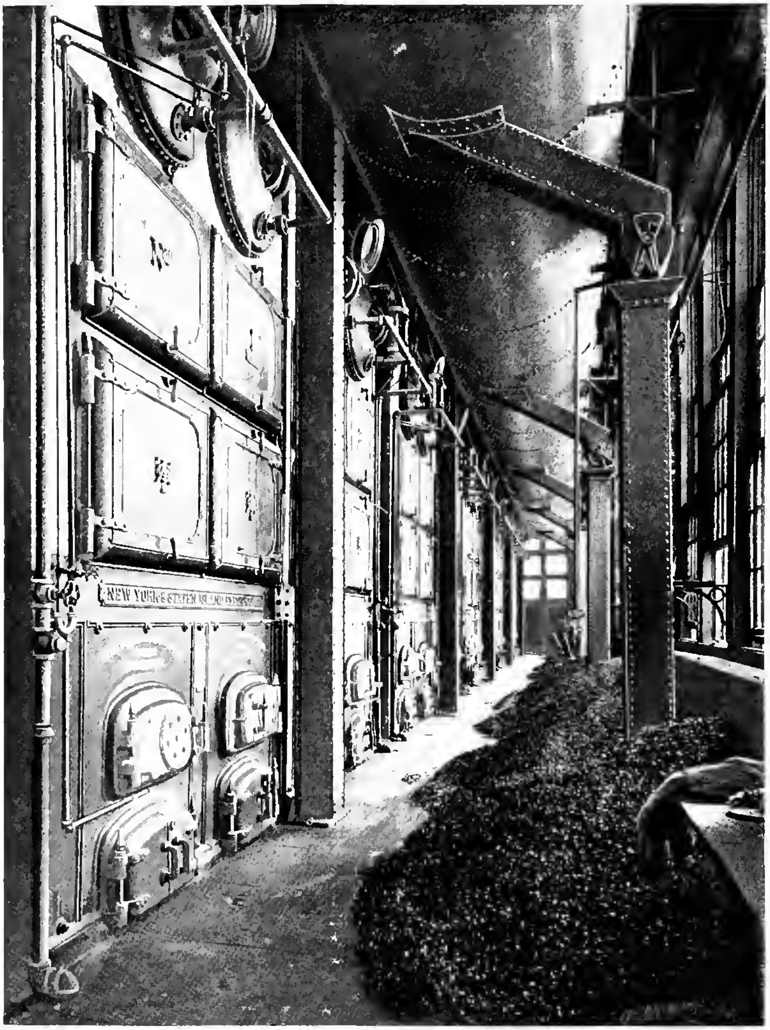


CARNEGIE STEEL CO., LTD., 48-INCH MILL, HOMESTEAD STEEL WORKS
4,000 H. P. CAHALL VERTICAL BOILERS AND CHAIN GRATE STOKERS

the plain flat grate, or hand firing, of from 10 to 15 per cent., and about three-fourths of the labor expense is saved in a steam plant thus equipped, the stokers being automatic. The fact that the majority of the leading mill owners throughout the country are having all their modern plants equipped with this device, and in many cases are having their old plants modernized through tearing out the old flat grates and substituting therefor the chain grate stoker, should, we think, speak volumes for the worth of the device.



MANSFIELD CHAIN GRATE STOKER
Showing how it can be withdrawn from under boiler



NEW YORK & STATEN ISLAND ELECTRIC CO., STATEN ISLAND, N. Y.
2,450 H. P. CAHALL HORIZONTAL BOILERS

The Advantages of the Cahall Boiler

1. Absolute safety from disastrous explosions, and the total absence of all cast metal in its construction.

2. Accessibility for cleaning, examination and repairs.

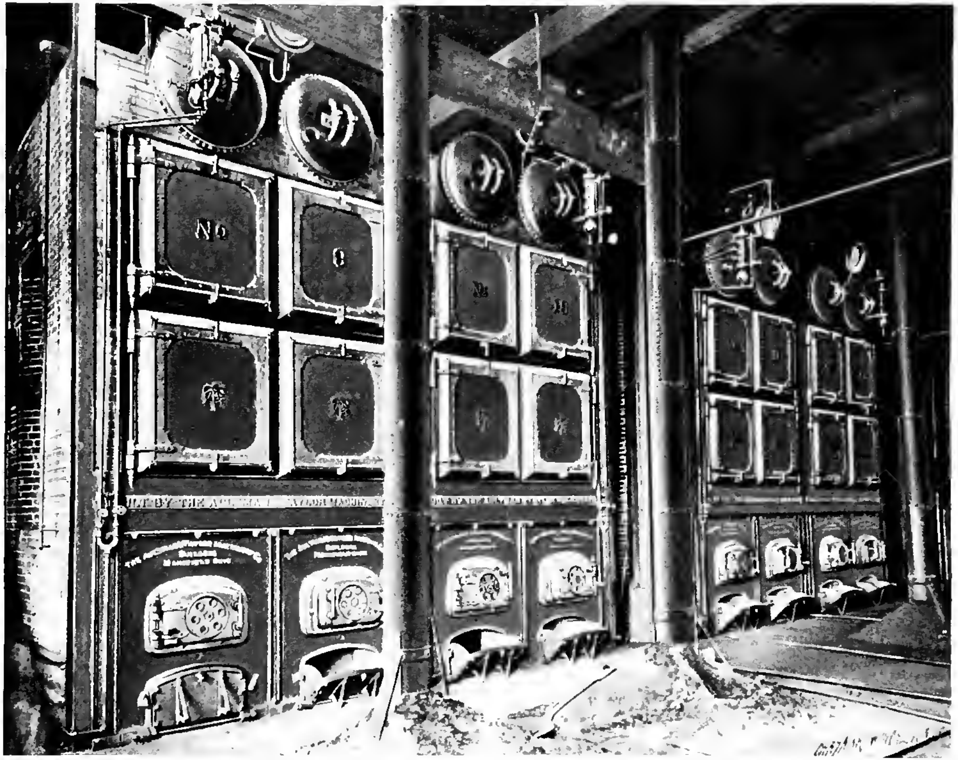
3. Special adaptability to situations where feed water is impure.

4. High pressure, every boiler being designed to carry a constant working pressure of 150 pounds.

5. Perfect circulation, tending toward preserving uniformity in the temperature in all parts of the boiler, thus doing away with the excessive strains due to the sudden heating and cooling of metals and the consequent loosening of parts.

6. The marked ease with which a tube may be removed and replaced. This feature is in striking contrast to the horizontal type, in which, in case a tube ruptures and gets out of shape, it frequently cannot be withdrawn through the hole in the tube sheet, but must be taken out by cutting away, on the side, above or below, as the case may be, as many tubes as prevent its removal.

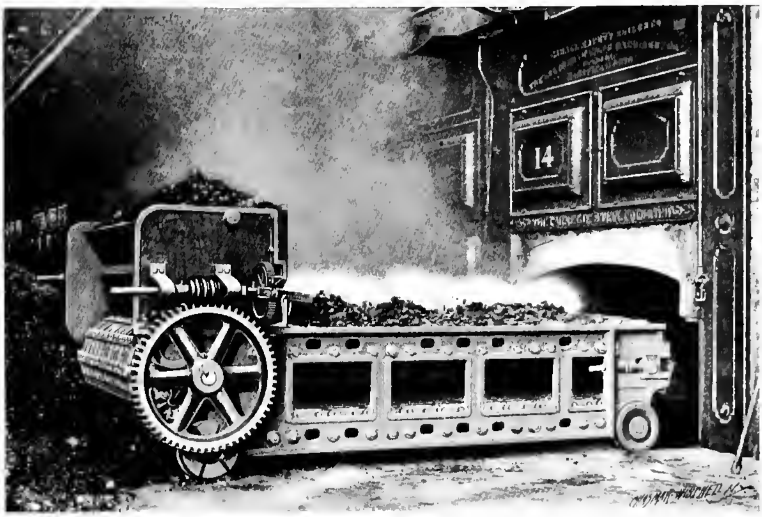
7. Economy in fuel, owing to the judicious arrangement of baffle tiling, by which the largest proportion of heat units contained in the gases are utilized in the most efficient manner, and the gases leave the boiler at a low temperature; owing also to the provisions that have been made for keeping both the inner and outer heating surfaces clean and free from accumulation of scale on the one hand, and soot and ashes on the other. This also tends to promote the durability and prolong the life of the boiler, as the danger of tubes



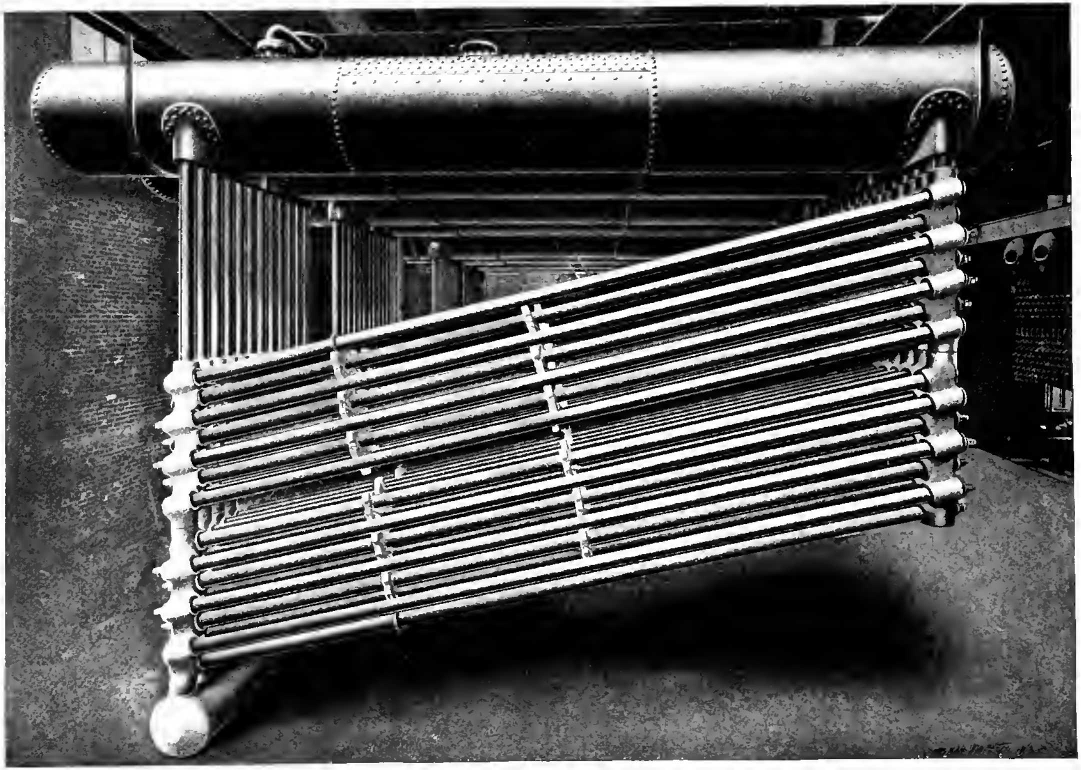
NEW YORK SUGAR REFINING CO., NEW YORK
5,333 H. P. CAHALL HORIZONTAL BOILERS

burning out is reduced to a minimum when they are kept clean both inside and out.

8. Economy in maintenance, due to its extreme simplicity, the ease with which it can be cleaned, and the readiness with which defective tubes may be removed and new ones inserted.



MANSFIELD CHAIN GRATE STOKER WITHDRAWN FROM BOILER SHOWING FIRE



THE NEW YORK SUGAR REFINING CO., LONG ISLAND CITY, N. Y.
5,333 H. P. CAHALL HORIZONTAL BOILERS, VERTICAL HEADER, DOUBLE DECK
SHOWING BOILERS SUSPENDED FROM FLOOR BEAMS

Tests of Cahall Boilers

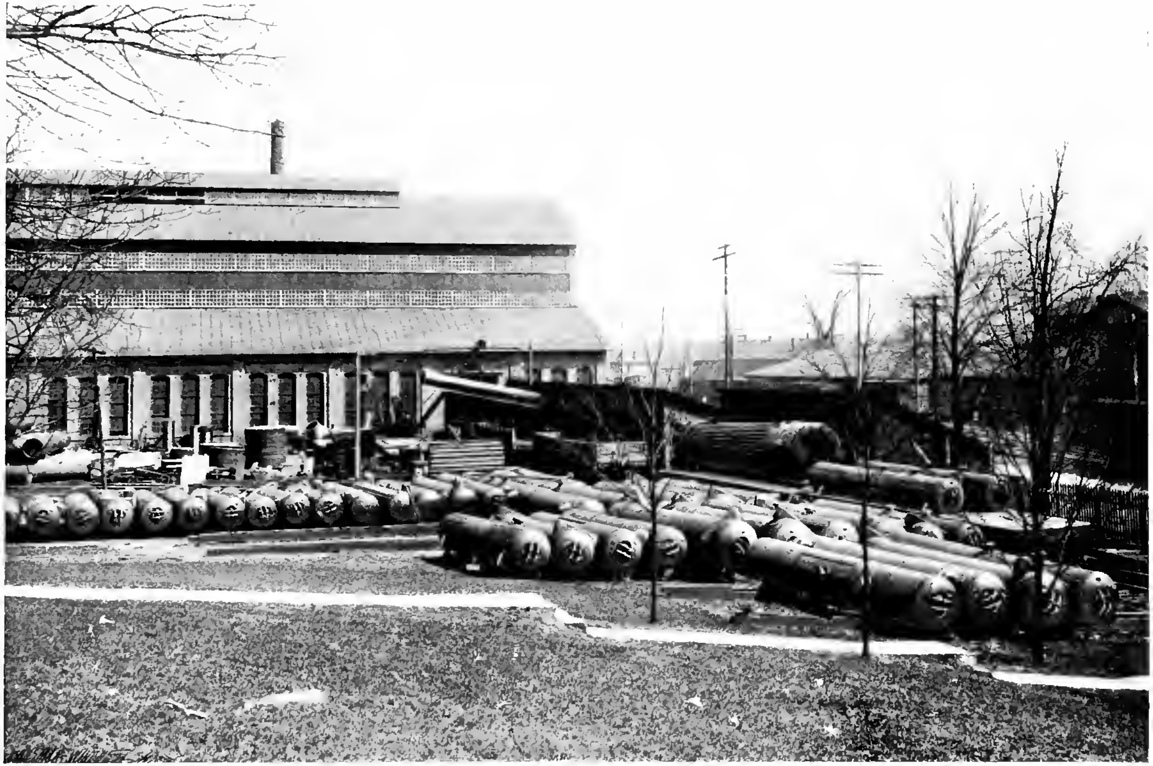
The Armstrong Cork Company, of Pittsburgh, Pa., having in use a 250 horse power Cahall boiler running in connection with other water tube boilers of a very well known make, and wishing to determine the exact performance of their Cahall boiler, from time to time made, through their own engineers, tests for efficiency and capacity. The results they obtained from their Cahall boiler in these tests appeared to them too high, being so very much better than anything they had ever been able to secure from the other water tube boilers in use at their works, so arrangements were made to have tests conducted to check theirs, by well known engineers from other cities. There have been in all nine tests made on this boiler, and we present them herewith.

It will be noticed on test No. 7, the boiler being run at 60 per cent. above its rating, showed an efficiency of over 71 per cent., while on test No. 6, the boiler being run only about 3 per cent. above its rating, showed an efficiency of nearly 86 per cent., while on test No. 2, with the boiler 11 per cent. above rating, the efficiency is nearly 82 per cent. Test No. 5, running 32 per cent. above rating, showed an efficiency of 79 per cent.

The nine tests made by different people at different times, with coals that vary in their general composition, extending over a period of eight months, during which time there was never a tube in the boiler scraped, show a wonderfully uniform series of results; the efficiency bearing almost a direct fixed ratio to the capacity in every test; the minimum efficiency being about 70 per cent. with the boiler driven at double its rating, the maximum over 85 per cent. with the boiler at about its normal horse power.

SUMMARY OF NINE TESTS MADE ON ONE 250 H. P. CAHALL BOILER AT FACTORY OF THE ARMSTRONG CORK CO., PITTSBURGH, PA.	1 By R. W. Hunt Co., of Chicago. (ECONOMY.)	2 By Armstrong Cork Co. (ECONOMY.)	3 By Armstrong Cork Co. (CAPACITY.)
Date of test	Jan. 9, 1896	Apr. 22, 1896	Apr. 23, 1896
Duration of test ... hours.	9	9	9
No. of boilers	1	1	1
Average Pressure of Steam in Boiler by Gauge ... lbs.	97.8	94	107
Average Temperatures:			
Of feed water entering boiler ... deg. F.	39.7	68	65
Of steam in boiler ... deg. F.	336	333.9	342.2
Fuel (kind of coal)	Nut N. Y. & C. Gas	Nut and slack Summer Hill	Nut and slack Summer Hill
Cost per ton of 2,000 pounds delivered	$1.10	$0.95	$0.95
Calorific power by calorimeter ... B. T. U.	13,100	12,420.4	12,420.4
Total quantity consumed ... lbs.	10,659	8,200	14,466
Total ash, clinkers and unburned coal ... lbs.	817	437	1,211
Proportion of ash, &c., to coal ... per cent.	7.6	5.33	8.3
Total combustible burned ... lbs.	9,602	7,763	13,255
Combustion per Hour:			
Coal actually consumed ... lbs.	1,157.6	911.11	1,607.3
Combustible actually consumed ... lbs.	1,066.9	862.55	1,473
Per square foot grate surface—coal ... lbs.	33.07	26.03	45.92
" " " " " combustible ... lbs.	30.48	24.64	42.08
Per square foot heating surface—coal ... lbs.	.445	.3505	.618
" " " " " combustible ... lbs.	.41	.3318	.566
Water—Amount apparently evaporated ... lbs.	90,112.75	72,757	120,503
Factor of evaporation	1.218	1.1885	1.1943
Equivalent evaporation into dry steam from and at 212° F. ... lbs.	109,757.3	86,471.69	143,916.73
Economic Evaporation—per pound of coal:			
Water actually evaporated ... lbs.	**8.648**	**8.87**	**8.33**
Equivalent from and at 212° F. ... lbs.	**10.533**	**10.54**	**9.95**
Per pound of combustible—water actually evaporated ... lbs.	9.384	9.37	9.01
Equivalent from and at 212° F. ... lbs.	**11.43**	**11.14**	**10.85**
Evaporation per Hour:			
Water actually evaporated ... lbs.	10,012.5	8,084.11	13,389.22
Equivalent from and at 212° F. ... lbs.	12,195.2	9,607.96	15,990.74
Per square foot heating surface—water actually evaporated ... lbs.	3.85	3.19	5.15
Equivalent from and at 212° F. ... lbs.	4.69	3.7	6.15
Per square foot grate surface—water actually evaporated ... lbs.	286.07	230.97	382.55
Equivalent from and at 212° F. ... lbs.	348.43	274.51	456.87
Efficiency:			
Percentage of total calorific power utilized, or efficiency ... per cent.	**77.7**	**81.97**	**77.39**
Water evaporated per $1.00 worth of fuel ... lbs.	19,638	22,186.7	20,895
Cost of evaporating 1,000 lbs. of water ... cents.	.052	.045	.0478
Coal consumed per horse power per hour ... lbs.	3.27	3.28	3.46
Cost of same ... cents.	.0018	.0015	.0016
Horse Power:			
Actually developed on basis of $34\frac{1}{2}$ lbs. water evaporated per hour from and at 212° F.	353.4	278.4	463.5
Commercial rating	250	250	250
Proportion capacity developed is of commercial rating ... per cent.	**141**	**111.36**	**185.4**
Heating surface required to develop one horse power ... square feet.	7.35	9.33	5.6

4	5	6	7	8	9	
By J. F. Swan. (CAPACITY.)	By J. F. Swan. (ECONOMY.)	By Thos. Pray, Jr., of Boston. (EFFICIENCY.)	By Thos. Pray, Jr., of Boston. (CAPACITY.)	By J. M. Whitham, of Philadelphia, Pa. (ECONOMY.)	By J. M. Whitham, of Philadelphia, Pa. (CAPACITY.)	AVERAGE.
Jan. 16, 1896	Jan. 16, 1896	May 4, 1896	May 5, 1896	Aug. 11, 1896	Aug. 12, 1896	
3½	3½	9	9	12	10	8⅔
1	1	1	1	1	1	1
98	95	96.39	100.58	97.4	103	98.8
44	44	68	68.2	82.7	83.7	62.6
336.5	334.5	326.6	329.5	....	....	334.2
Run of mine	Run of mine	Slack	Slack	Sandy Creek	Sandy Creek	
N. Y. & C. Gas	N. Y. & C. Gas	Summer Hill	Summer Hill	N. Y. & C. Gas	N. Y. & C. Gas	
$1.10	$1.10	$0.95	$0.95	$1.00	$1.00	$1.01
13,100	13,100	12,854	13,850	....	....	12,963.5
4,949	3,734.5	7,138	12,893	11,561	17,595	10,132.8
376.22	283.82	1,271.5	1,614	1,148	1,617	975.06
7.6	7.6	18.18	12.774	10.4	9.5	9.69
1,572.88	3,450.68	5,722.78	11,021.14	9,864	15,406	8,961.94
1,414	1,067	771.14	1,403.9	....	....	1,190.29
1,306.53	985.9	635.86	1,224.59	....	....	1,082.79
40.4	30.4	22.204	40.112	24.6 and 11.6	45.6 and 21.4	31.03
37.32	28.16	18.167	34.987	....	....	32.54
.543	.41	.3116	.56291	....	....	.47
.502	.379	.25495	.491	....	....	.43
39,700.5	32,949	65,949	107,234	99,176	147,411	86,199.08
1.2142	1.2136	1.1862	1.1871	....	....	1.2
48,204.347	39,987.506	79,936	129,130	116,533	173,133	103,007.73
8.021	**8.822**	**9.6347**	**8.6094**	**9.02**	**8.66**	**8.735**
9.74	**10.707**	**11.429**	**10.22**	**10.58**	**10.17**	**10.43**
8.681	9.548	11.776	9.8703	....	....	9.1106
10.5404	**11.587**	**13.968**	**11.717**	**11.81**	**11.24**	**11.5869**
11,343	9,414	7,487.6	12,087	....	....	10,448.57
13,772.66	11,425	8,881.8	14,348	9,711	17,313	12,582.82
4.36	3.62	3.0022	4.8463	....	....	4.03
5.29	4.39	3.8159	5.8869	3.69	6.58	4.9571
324.08	268.97	213.93	345.34	....	....	298.53
393.48	326.42	253.76	409.94	260.5 and 122.6	463 and 218	320.68
71.88	**79.01**	**85.862**	**71.259**	....	....	**77.867**
17,707.32	19,465.32	23,624	25,435	....	....	19,858.47
.0564	.0513	.04233	.039315	.0472	.0492	.0498
3.54	3.22	3.0174	3.3743	....	....	3.35
.001947	.001771	.001459	.0016028	....	....	.001724
399.2	330.97	257.55	416.055	281.5	501.8	364.708
250	250	250	250	250	250	250
159.68	**132.39**	**103.02**	**166.422**	**112.76**	**200.7**	**145.859**
6.51	7.85	9.0374	5.9945	9.33	5.24	7.3602



VIEW OF STORAGE YARD, CAHALL FACTORY, SHOWING DRUMS FOR CAHALL HORIZONTAL BOILERS

Tests made by Thomas Pray, Jr., of Boston, Mass.

(Case 3665)

Cahall Boiler, 250 Horse Power (maker's rating), with Hawley Down Draft Furnace, at Armstrong Cork Co.'s Works, Twenty-fourth and Railroad Streets, Pittsburgh

1	Date of trial, May 4, 1896.	
2	Duration, 8 A.M. to 5 P.M. (no noon hour)	9 hours

Dimensions and Proportions

3	Grate surface, 7 x 5 feet	35 sq. ft.
4	Water heating surface	2,494 sq. ft.
5	Superheating surface	140 sq. ft.
6	Ratio of water heating to 1 of grate surface	71.257

Average Pressures

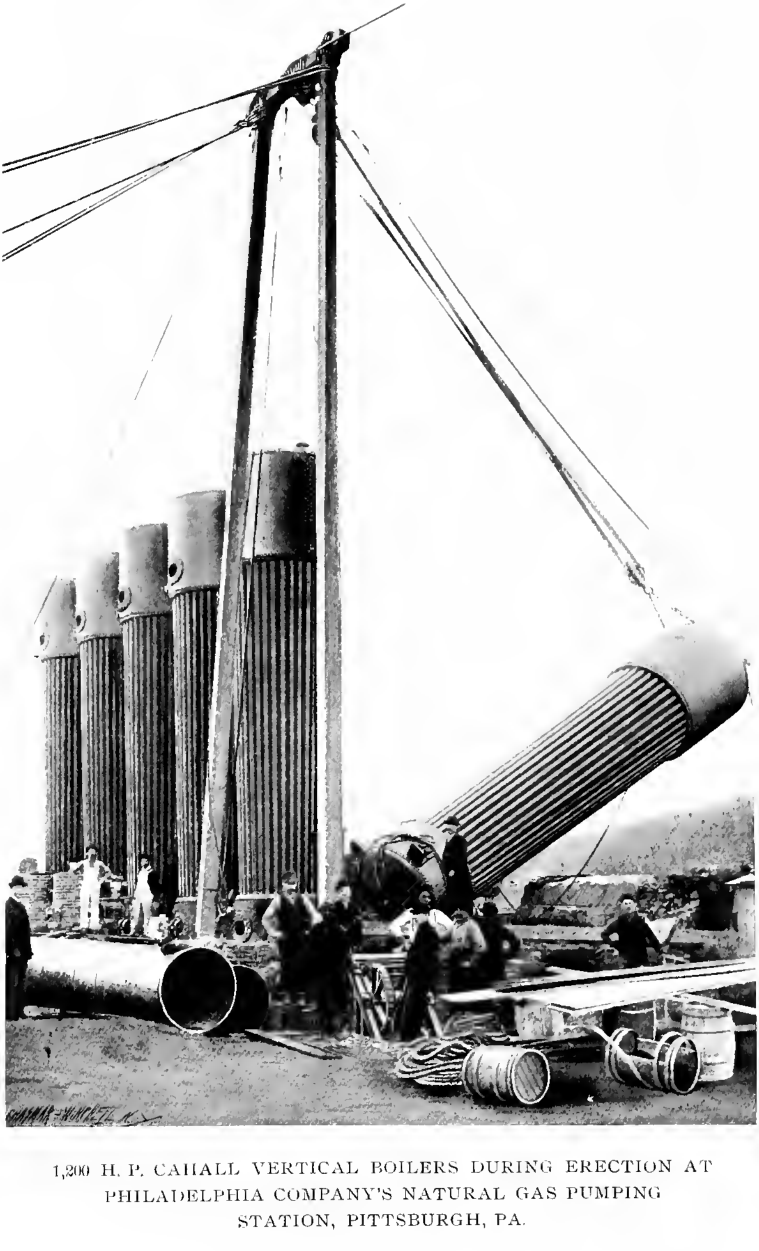
7	Pressure by gauge	96.39 lbs.
7*a*	Error of water column	12.592 lbs.
7*b*	Correct steam gauge pressure	83.798 lbs.
8	Absolute pressure	98.73 lbs.
9	Barometer (U. S. Signal Service)	30.4 in.
9*a*	Atmospheric pressure	14.932 lbs.
10	Force of draft in inches of water	.6 in.

Average Temperatures

11	External air	71° F.
12	Fire room	93° F.
13	The steam, 98.730 lbs. absolute	326.6° F.
14	Escaping gases	403.05° F.
15	Feed water	68° F.

Fuel

16	Total amount of coal from the pile	7,138 lbs.
17	Percentage of moisture in the coal	2.0134 per cent.
17*a*	Pounds of moisture in the coal	143.72 lbs.



1,200 H. P. CAHALL VERTICAL BOILERS DURING ERECTION AT PHILADELPHIA COMPANY'S NATURAL GAS PUMPING STATION, PITTSBURGH, PA.

18	Dry coal	6,994.28 lbs.
19	Ash and cinders	1,271.5 lbs.
19*a*	Percentage of ash and cinders	18.18 per cent.
19*b*	Pounds of moisture, ash and cinders	1,415.22 lbs.
19*c*	Total loss in coal from all causes	19.827 per cent.
20	Pounds of combustible	5,722.78 lbs.
21	Dry coal consumed per hour	777.14 lbs.
22	Combustible consumed per hour	635.86 lbs.

Results of Calorimetric Tests

23	Quality of the steam (dry steam being taken as unity)	1.02184
24	Percentage of moisture in steam	0.0000000
25	Number of degrees superheat	40.238° F.
25*a*	Percentage of superheat	2.184 per cent.

Water

26	Total quantity of water pumped into the boiler and apparently evaporated	65,949 lbs.
27	Water actually evaporated, corrected for quality of steam	67,388 lbs.
28	Equivalent water evaporated into dry steam at and from 212° F	79,936 lbs.
28*a*	Factor of evaporation	1.1862
29	Equivalent B. T. U. from the fuel	77,194,000
30	Equivalent water evaporated into dry steam at and from 212° F. per hour	8,881.8 lbs.

Economic Evaporation

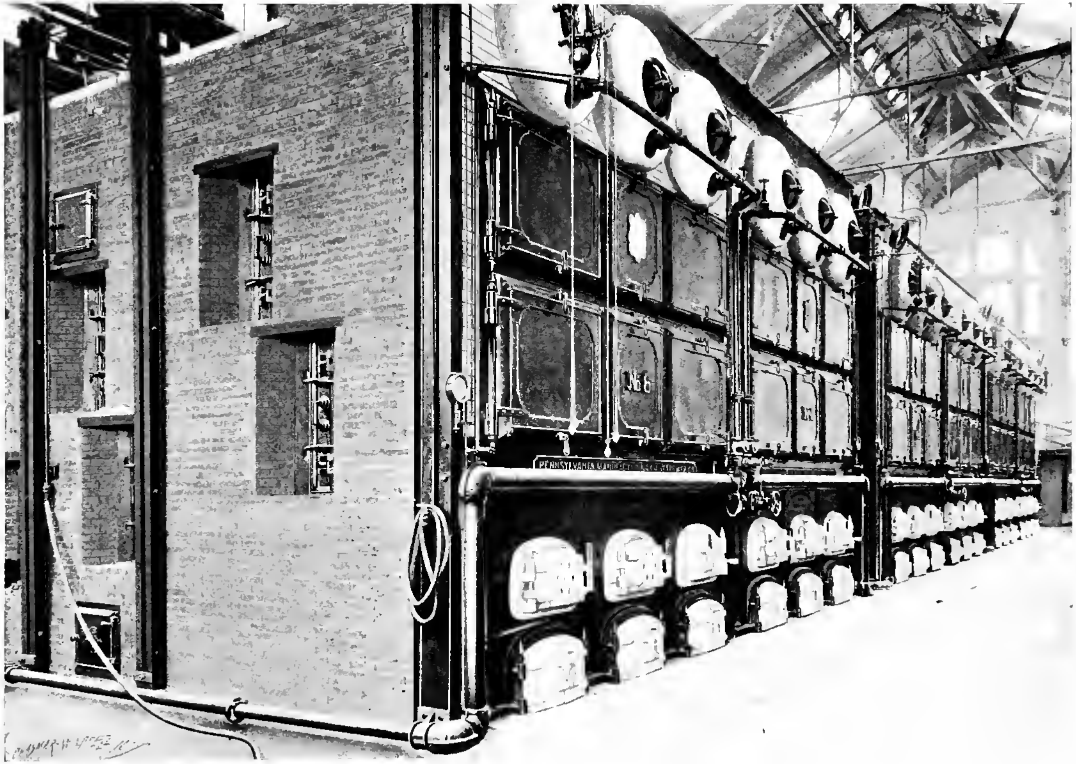
31	Water actually evaporated per pound of dry coal, from actual pressure and temperature	**9.6347** lbs.
32	Equivalent water evaporated per pound of dry coal at and from 212° F.	**11.429** lbs.
33	Equivalent water evaporated per pound combustible at and from 212° F.	**13.968** lbs.

Commercial Evaporation

34	Equivalent water evaporated per pound of dry coal, with one-sixth refuse, at 70 lbs. gauge pressure, from temperature of 100° F.	10.126 lbs.

Rate of Combustion

35	Dry coal actually burned per sq. ft. of grate surface each hour	22.204 lbs.
35*a*	Dry coal actually burned per sq. ft. of heating surface	.3116 lbs.



PENNSYLVANIA MANUFACTURING, LIGHT, HEAT & POWER CO., PHILADELPHIA, PA.
4,808 H. P. CAHALL HORIZONTAL BOILERS

Rate of Evaporation

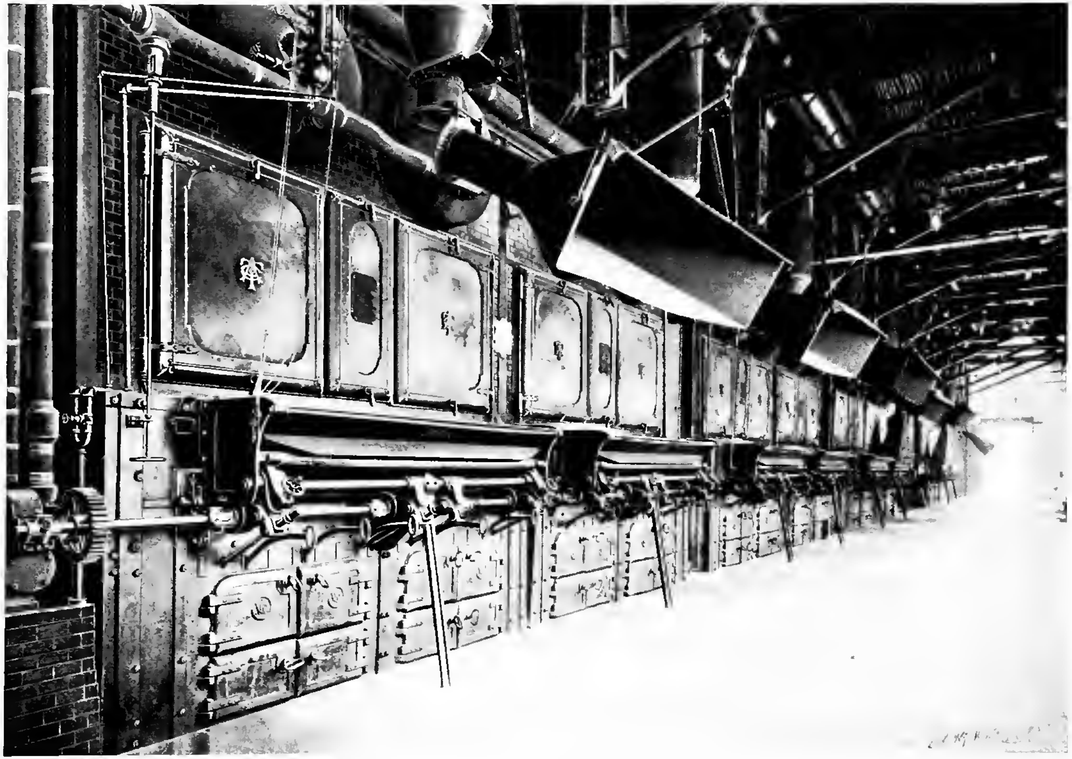
39	Water evaporated at and from 212° F. per sq. ft. of heating surface each hour	3.8159 lbs.
39*a*	Water evaporated at and from 212° F. per sq. ft. of grate surface each hour	253.76 lbs.

Commercial Horse Power

43	Horse power of boiler per American Society of Mechanical Engineers' code	**257.55** H. P.
44	Horse power of boiler (builder's rating), 10 sq. ft. per horse power	**250** H. P.
45	Horse power in excess of maker's rating in the performance of the boiler	**3.02** per cent.
45*a*	Sq. ft. of heating surface for one horse power	9.0374
45*b*	Sq. ft. of grate surface for one horse power	.1359

Efficiency

46	Heat units accounted for in the water for one lb. of dry coal	11,037 B. T. U.
47	Heat units in one lb. of coal by the "Bomb Calorimeter"	12,854 B. T. U.
48	Efficiency of boiler performance in percentage of the theoretical value of the coal as above	**85.862** per cent.
49	Cost of coal per ton (2,000 lbs.)	95 cents
50	Possible evaporation for one lb. of coal, actual conditions	11.2214 lbs.
50*a*	Actual evaporation under working conditions (see item 31)	9.6347 lbs.
51	Percentage of possible evaporation realized under actual conditions	85.862 per cent.
52	Heat units in one ton of coal	25,708,000 B. T. U.
53	Heat units required to make one ton of water into steam, actual conditions	2,291,000 B. T. U.
54	Possible tons of water into steam with a ton of dry coal	11.2214 tons
55	Cost of 2,000 lbs. of water into steam, actual conditions	8.4661 cents
56	Pounds of water into steam for one cent, actual conditions	236.24 lbs.
57	Horse powers of 34.488 lbs. of water per hour at and from 212° F., A. S. M. E. code or its equivalent, 30 lbs., from 100° F., to 70 lbs. steam guage pressure, for one cent	6.8503 H. P.
58	Cost of one horse power of steam one hour, in fraction of a cent	.146



CAPITAL TRACTION CO., WASHINGTON, D. C.
2,500 H. P. CAHALL HORIZONTAL BOILERS—TWO ORDERS

59	Heat units for one cent	270,620 B. T U.
60	Theoretical loss of possible heat units, all sources	14.138 per cent.

(Signed) THOMAS PRAY, JR.

(Case 3666)

Cahall Boiler, 250 Horse Power (maker's rating), with Hawley Down Draft Furnace, at Armstrong Cork Co.'s Works, Twenty-fourth and Railroad Streets, Pittsburgh

1	Date of trial, May 5, 1896.	
2	Duration, 8 A. M. to 5 P. M. (no noon hour)	9 hours

Dimensions and Proportions

3	Grate surface, 5 ft. long by 7 ft. wide	35 sq. ft.
4	Water heating surface	2,494 sq ft.
5	Superheating surface	140 sq. ft.
6	Ratio of water heating surface to 1 of grate surface	71.257

Average Pressures

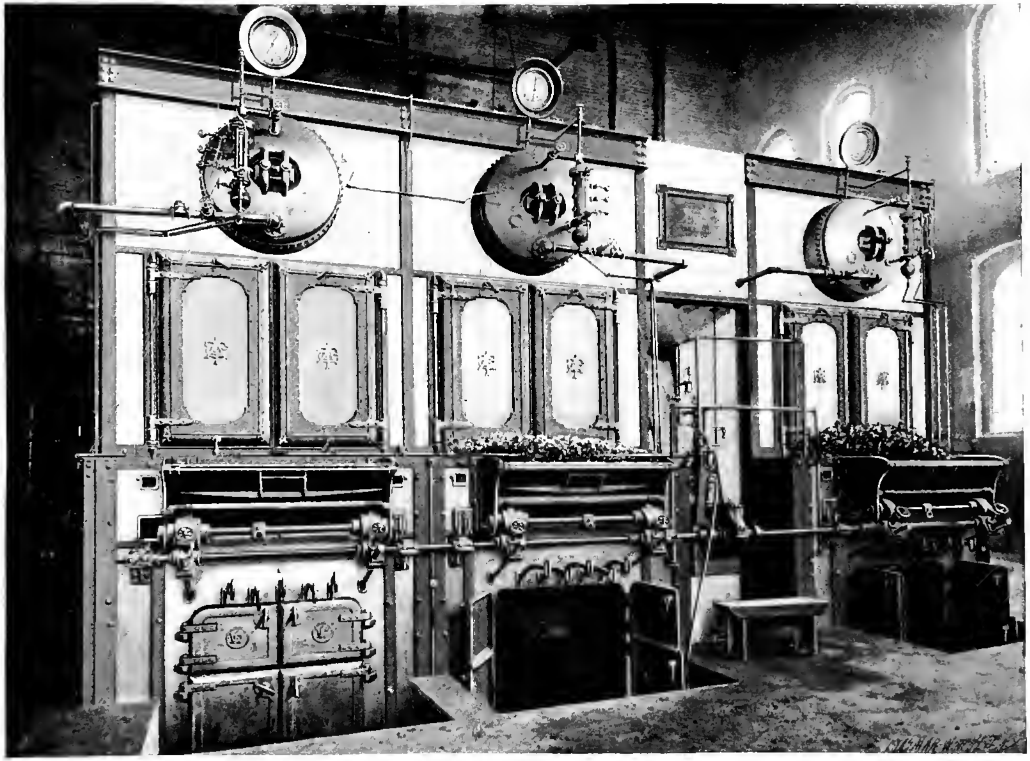
7	Steam pressure in boiler by gauge	100.58 lbs.
7*a*	Error of water column	12.592 lbs.
7*b*	Correct steam gauge pressure	87.988 lbs.
8	Absolute pressure per sq. in.	102.699 lbs.
9	Barometer (U. S. Signal Service)	29.95 in.
9*b*	Atmospheric pressure in lbs. per sq. in.	14.711 lbs.
10	Force of draft in inches of water	.6324 in.

Average Temperatures

11	Of external air	78° F.
12	Of fire room	96° F.
13	Of the steam at 102.699 lbs. per square inch	329.5° F.
14	Of escaping gases	477.772° F.
15	Of the feed water	68.2° F.

Fuel

16	Total amount of coal from the pile	12,893 lbs.
17	Moisture in the coal	2 per cent.
17*a*	Moisture in the coal	257.86 lbs.



CITY OF CHICAGO (14TH STREET PUMPING STATION)
537 H. P. CAHALL HORIZONTAL BOILERS OF "FLOWED" STEEL CONSTRUCTION

18	Dry coal	12,635.14 lbs.
19	Ashes and cinders	1,614 lbs.
19*a*	Ashes and cinders	12.774 per cent.
19*b*	Pounds of moisture, ashes and cinders	1,871.86
19*c*	Total losses in coal, from all causes	14.5188 per cent.
20	Pounds of combustible	11,021.14
21	Dry coal consumed per hour	1 403.9 lbs.
22	Combustible consumed per hour	1,224.59 lbs.

Results of Calorimetric Tests

23	Quality of the steam, dry steam being taken as unity	1.01443
24	Moisture in the steam	0.000000
25	Number of degrees of superheat	26 499
25*a*	Percentage of superheat	1.443
26	Total quantity of water pumped into the boiler and apparently evaporated	107,234 lbs.
27	Water actually evaporated, corrected for the quality of the steam	108,780 lbs.
28	Equivalent water evaporated into dry steam at and from 212° F.	129,130 lbs.
28*a*	Factor of evaporation	1.1871
29	Equivalent British Thermal Units from the fuel	148,030,000
30	Equivalent water evaporated into dry steam at and from 212° F., per hour	14,348 lbs.

Economic Evaporation

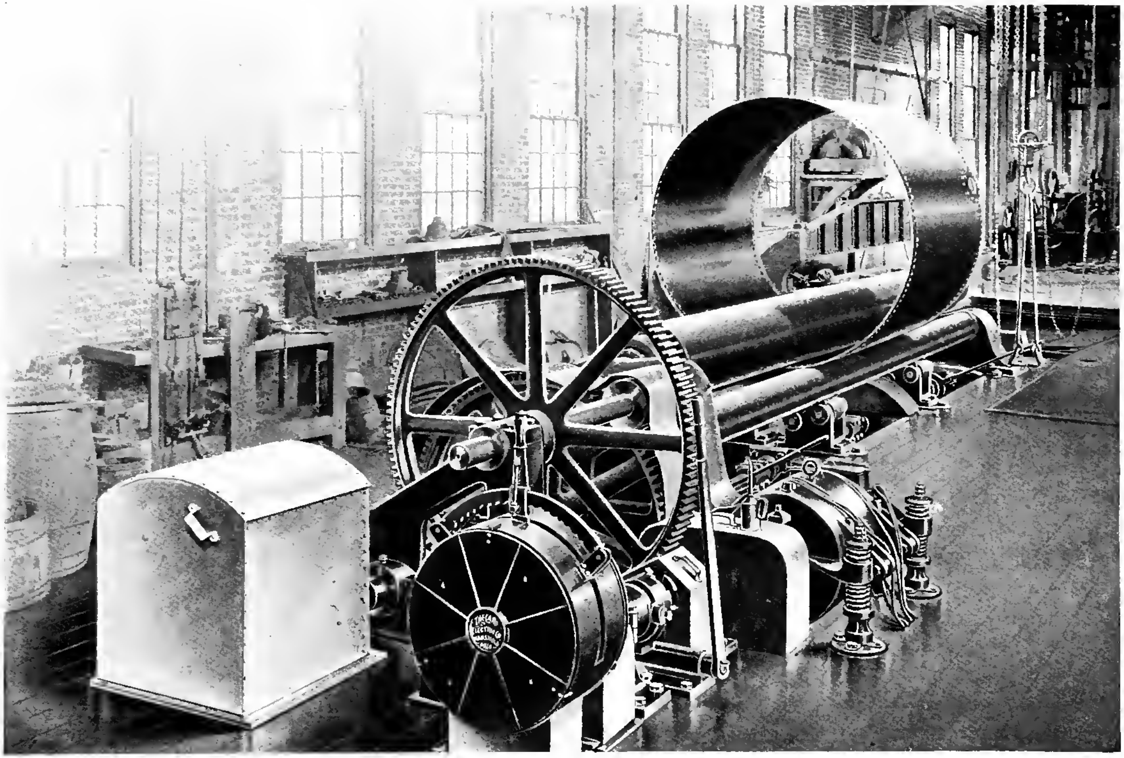
31	Water actually evaporated per pound of dry coal, from actual pressure and temperature	**8.6094** lbs.
32	Equivalent water evaporated per pound of dry coal at and from 212° F.	**10.22** lbs.
33	Equivalent water evaporated per pound of combustible at and from 212° F.	**11.717** lbs.

Commercial Evaporation

34	Equivalent water evaporated per lb. of dry coal, with one-sixth refuse, at 70 lbs. gauge pressure, from temperature of 100° F.	8.4936 lbs.

Rate of Combustion

35	Dry coal actually burned per sq. ft. of grate surface each hour	40.112 lbs.
35*a*	Dry coal actually burned per sq. ft. of heating surface each hour	.56291 lbs.



TWENTY-FOOT BENDING ROLLS, CAHALL FACTORY

Rate of Evaporation

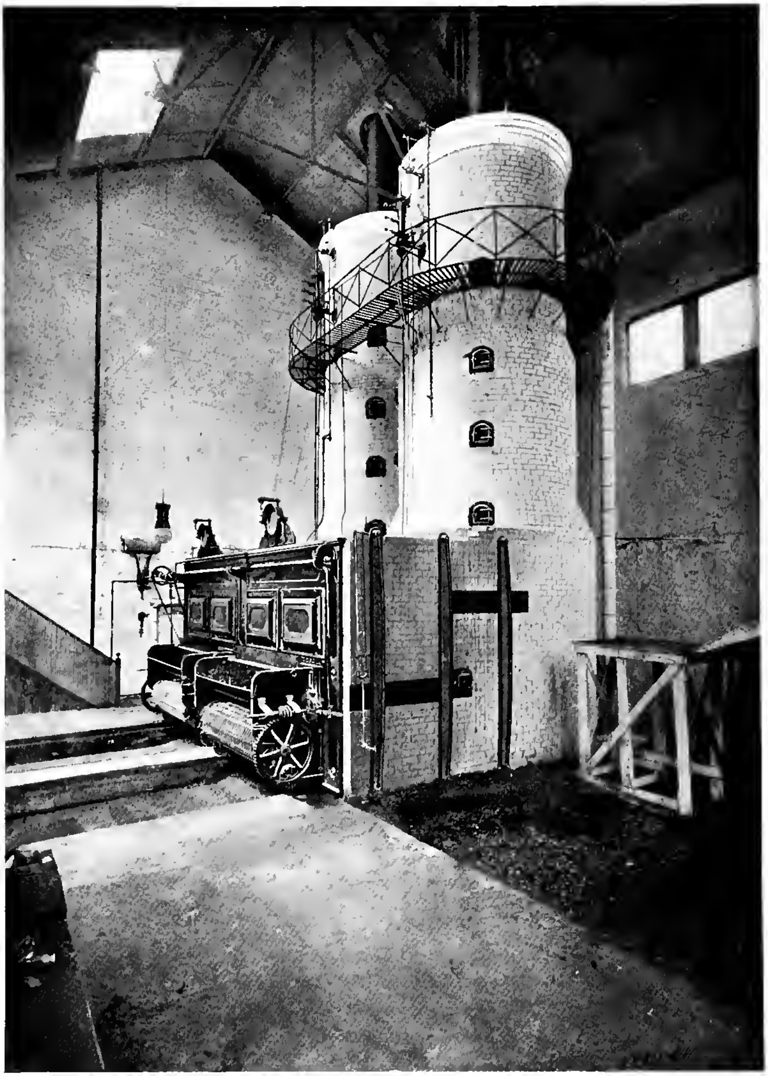
39	Water evaporated at and from 212° F. per sq. ft. of heating surface each hour	5.8869 lbs.
39*a*	Water evaporated at and from 212° F. per sq. ft. of grate surface each hour	409.94 lbs.

Commercial Evaporation

43	Horse power of boiler, per American Society of Mechanical Engineers' code, on basis of 30 lbs. of water per hour evaporated from temperature of 100° F. into steam of 70 lbs. gauge pressure = 34.5 lbs., from and at 212° F. . .	**416.055**
44	Horse power of boiler (builder's rating), 10 sq. ft. of heating surface per horse power . . .	**250** H. P.
45	Excess of maker's rating in the performance of the boiler	**66.422** per cent.
45*a*	Square feet of heating surface for one horse power	5.9945
45*b*	Square feet of grate surface for one horse power .	.084318

Efficiency

46	Heat units accounted for in the water for one lb. of dry coal	9,869 B. T. U.
47	Heat units in one lb. of coal by the calorimeter (3 tests)	13,850 B. T. U.
48	Efficiency of boiler performance in percentage of theoretical value of the coal as above . .	**71.259** per cent.
49	Cost of coal per ton (2,000 lbs.)	95 cents
50	Possible evaporation per lb. of coal, actual conditions	12.082 lbs.
50*a*	Actual evaporation under working conditions (see item 31)	8.6094 lbs.
51	Percentage of possible evaporation realized under actual conditions	71.259
52	Heat units in one ton of coal (2,000 lbs.) .	27,700,000 B.T.U.
53	Heat units required to make one ton of water into steam, actual conditions	2,292,740 B.T.U.
54	Possible weight of water into steam with a ton of dry coal	12.082 tons
55	Cost of 2,000 lbs. of water into steam	7.863+ cents
56	Pounds of water into steam for one cent . .	254.35 lbs.
57	Horse power of 34.488 lbs. of water per hour at and from 212° F., American Society Mechanical Engineers' code or its equivalent, 30 lbs. from 100° F. to 70 lbs. steam gauge pressure for one cent	7.3758 H. P.



BULLOCK ELECTRIC MANUFACTURING CO., CINCINNATI, OHIO
500 H. P. CAHALL VERTICAL BOILERS AND CHAIN GRATE STOKERS

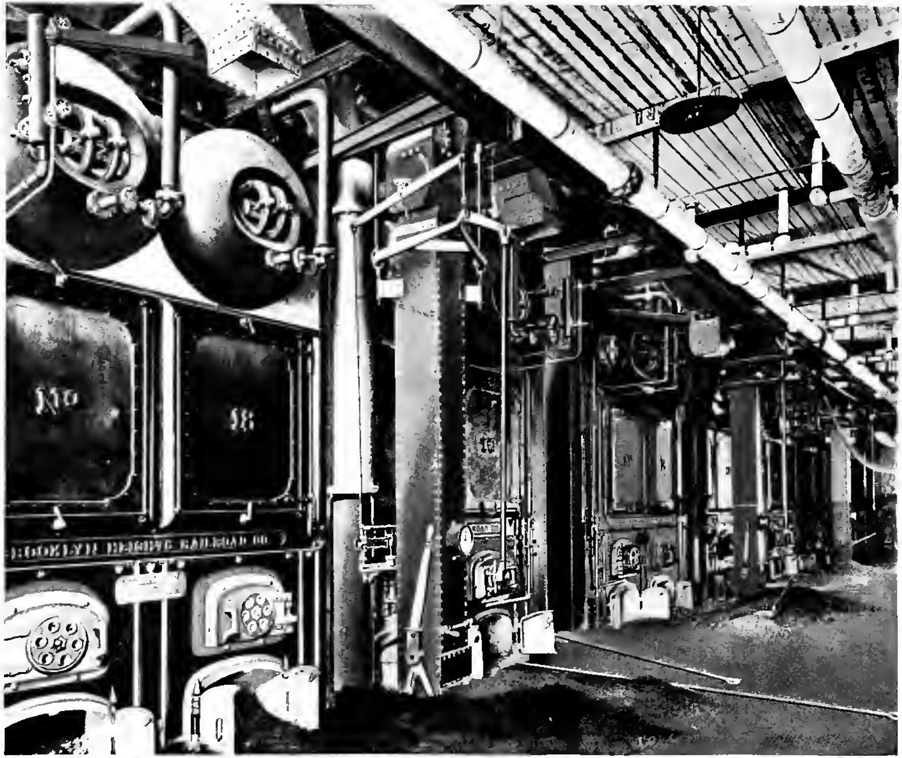
58	Cost of one horse power of steam one hour in fraction of one cent	.136
59	Heat units for one cent	291,582 B. T. U.
60	Theoretical loss of possible heat, all sources	28.741 per cent.

The Bomb Calorimetric results were done for me at Cornell University, and received on May 26, at which time I was hundreds of miles away on similar work; could not finish the computations sooner.

(Signed) THOMAS PRAY, JR.

Boston, May 14, 1896

ARMSTRONG CORK CO., PITTSBURGH, PA.
500 H. P. CAHALL VERTICAL BOILERS



BROOKLYN HEIGHTS ELECTRIC RAILROAD CO., BROOKLYN, N. Y.
2,500 H. P. CAHALL HORIZONTAL BOILERS

Final Report and Results of Tests made at Armstrong Cork Company, Pittsburgh, Pa., May 4 and 5, 1896

(Cases Nos. 3665 and 3666)

Full Report Herewith, as Rendered

This final report deals only with the chemical analyses of coal used on days as above, and the results as computed by me in my usual practice, items 46 to 60, inclusive (these items are computed strictly with the code of the A. S. M. E., but are not recognized in that code as it now stands on the Transactions of that Society).

Chemical analyses were made at the Cornell University for me, and the determination of the theoretical British Heat Units in a pound of coal was also made at Cornell.

In the computation of the B. T. U. of coal with so high a percentage of volatile, the most reliable formulæ are sadly at fault, hence I have adopted the "Bomb Calorimeter" determination, in place of some of the so-called utterly unreliable "Coal Calorimeters," and in such tests prefer to employ entirely disinterested persons to do this work, than to do it myself, although familiar with the work.

The coal used was sampled from each two hundred pounds and a final sample drawn from this amount and put into a tin can, soldered up in the yard, and sent away to the chemist each day. The coal was shoveled off the cars in the yard of the Armstrong Co.,

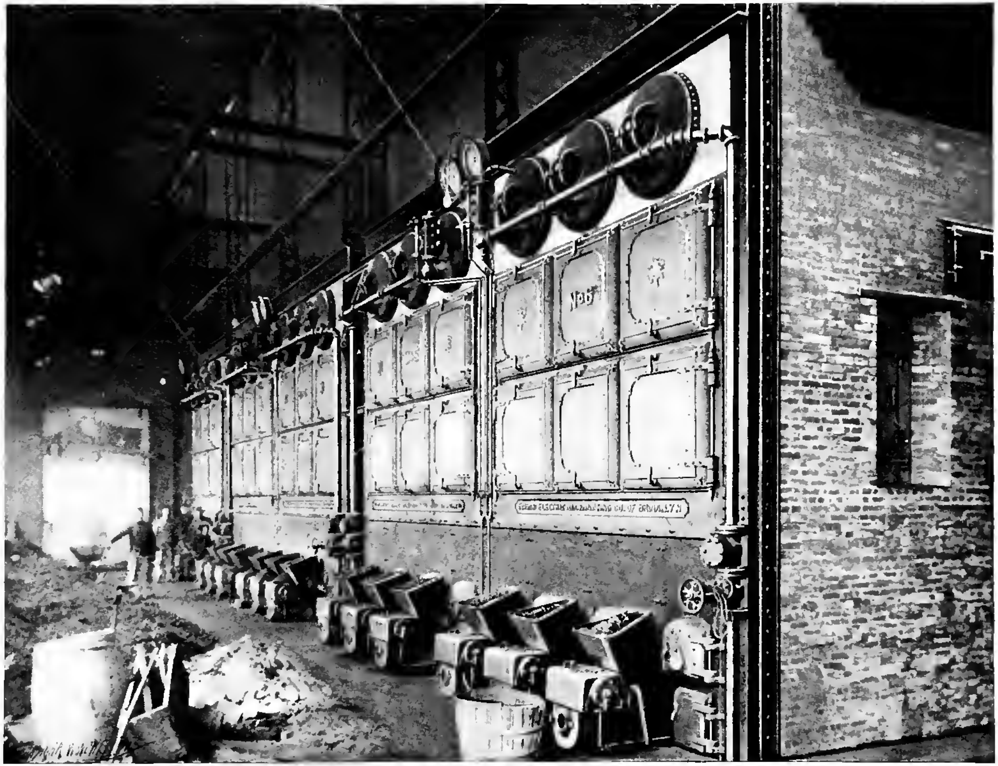
AMERICAN FILE CO., PAWTUCKET, R. I.

at various times each day, or as the men had the time to do it.

The test of the Cahall boiler for capacity is one of the best I have seen, in over four thousand boilers already tested, without one exception; a boiler rated by builders as 250 horse power, under American Society of Mechanical Engineers' code, of 34.4876 pounds of water at and from 212 degrees Fahrenheit, or its equivalent, which calls for the use of 33,305 B. T. U. an hour, whatever the pressure and temperature may be under actual conditions.

That this boiler did for nine hours easily, and could have done for nine days, *one hundred and sixty-six and four hundred and twenty-two one thousandths* per cent. of that rating, or 416.055 horse powers, with an efficiency of 10.22 pounds of water at and from 212 degrees Fahrenheit with one pound of *dry coal*, and the fires not managed at their best, is certainly not other than an extraordinary result; no sort of change was made from its usual every day conditions; it was not, as in some similar cases, done with a grate surface cut down, or some other factor changed, but it was an every day test, by the regular fireman of the concern who owned the boiler, and this man ran it to suit himself (it was not a particle of use to suggest to him), and under these conditions, 71.259 per cent. of the possible heat units by laboratory test were accounted for in the water and steam; the whole day had a superheat in the steam amounting to 1.443 per cent. or 26.499 degrees Fahrenheit above temperature due to pressure.

I regret not being able to send this final report sooner, but it requires time to do properly the chemical analyses of coal, and in these cases more than one determination of each has been made; the variation between any two is almost immaterial, but the average of three in each case is considered as final.



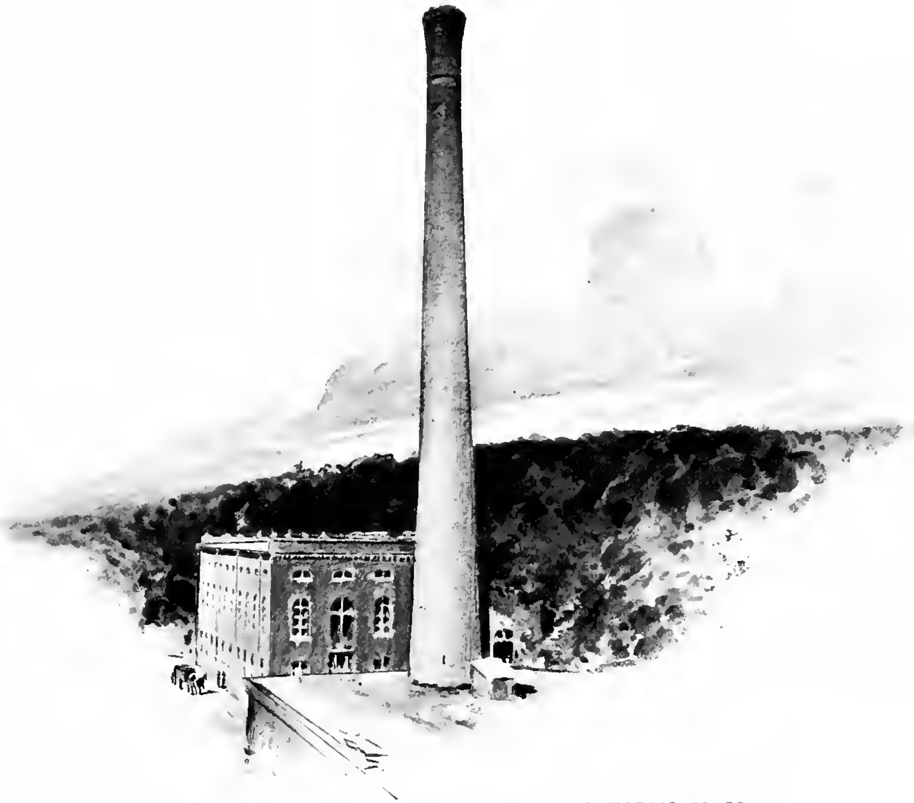
BROOKLYN EDISON CO., BROOKLYN, N. Y.
3,726 H. P. CAHALL HORIZONTAL BOILERS

When the analyses came, I was away, and now improve first day possible to forward you, and am certain that the results will interest steam users who are looking for facts.

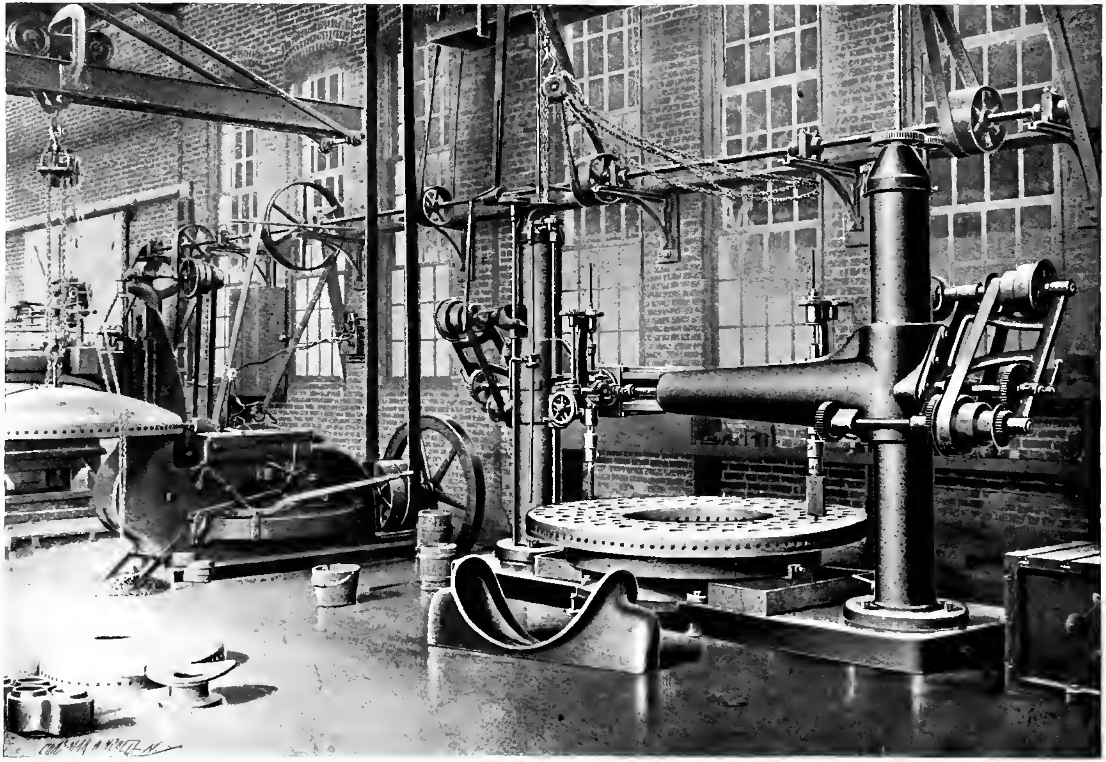
All of which is respectfully submitted.

THOMAS PRAY, JR.

Boston, June 2, 1896.
95 Milk Street, Room 71.



BOILER HOUSE, LANCASTER MILLS, CLINTON, MASS.
2,750 H. P. CAHALL VERTICAL BOILERS



ONE OF THE DOUBLE RADIAL DRILLS, CAHALL FACTORY

Test Made on a Cahall Waste Heat Boiler at the Republic Iron Works, Pittsburgh, Pa., by the Pittsburgh Testing Laboratory, June 2 and 3, 1893

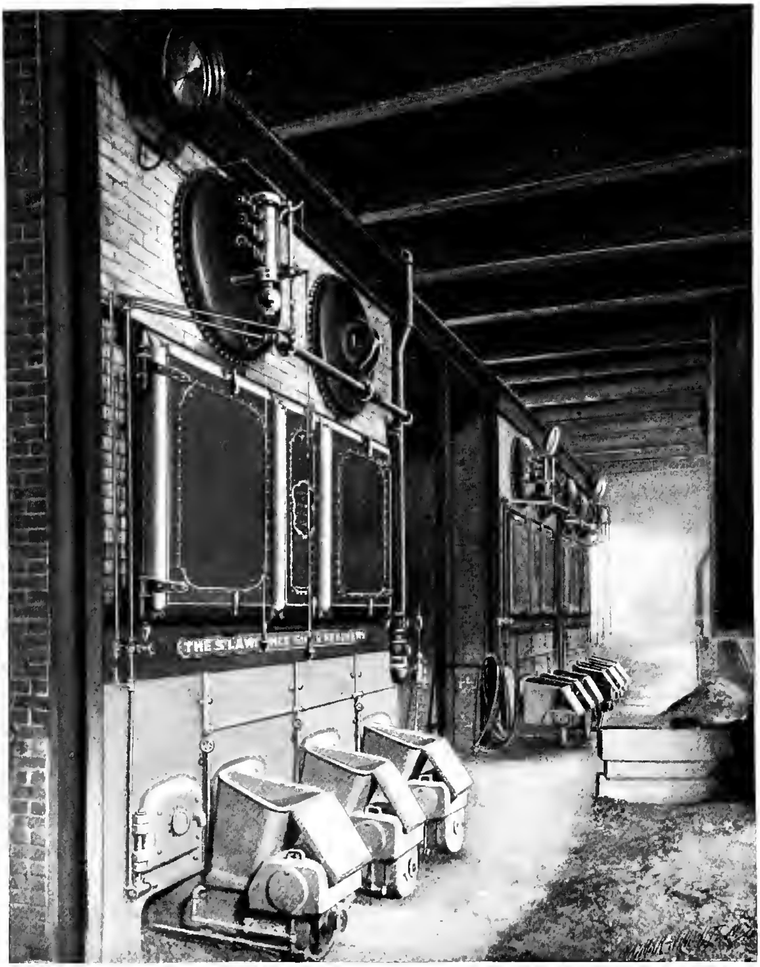
DURATION OF TEST.—The test was run from 4 P.M. on June 2 to 3 A.M. on June 3 (11 hours), which was from charge to charge of furnace. During the last half hour, while they were making new bottoms, no gas was used.

BOILER.—The boiler tested was a Cahall Patent Vertical Water Tube Boiler, having seventy-two 4-inch and six 5-inch tubes, on 1332.4 square feet of heating surface. Diameter of steam drum, 60 inches; height, 80 inches; diameter of mud drum, 78 inches; height, 42 inches; diameter of up-take through mud drum, 38 inches. Rated by the makers as 125 horse power.

The boiler was connected with a single re-heating furnace, and used the waste gases as fuel. During the test seven heats were made, and the total weight of the finished iron was 25,300 pounds, being rather more than the amount finished by other furnaces in many works running eight heats.

FUEL.—The fuel used by the re-heating furnace was natural gas. The following is an analysis of same:

Carbon dioxide	0.7 per cent.
Illuminants	0.2 " "
Oxygen	0.1 " "
Carbon monoxide	0.5 " "
Hydrogen	None.
Marsh gas	64.5 per cent.
Nitrogen	34.0 " "
	100.0 per cent.



ST. LAWRENCE SUGAR REFINING CO., MONTREAL, CANADA
USING 1,500 H. P. CAHALL HORIZONTAL BOILERS

The large amount of free nitrogen in the gas would account for its rather low efficiency. The heat units per cubic foot of this gas were 682.36 B. T. U.

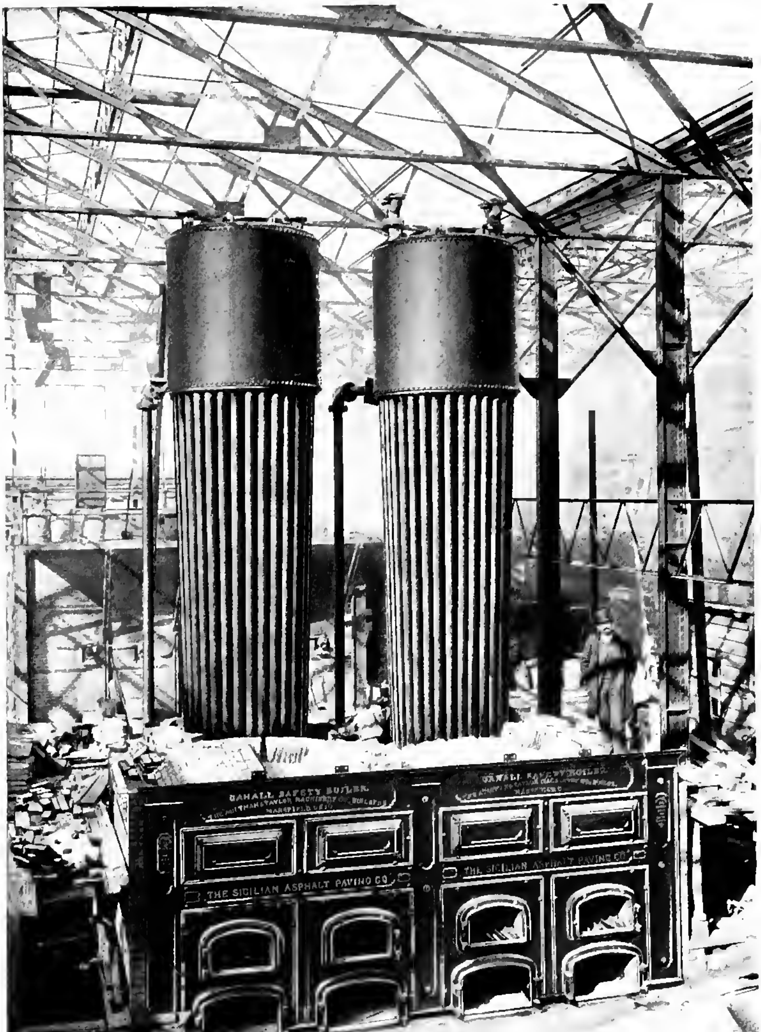
The following is the analysis of the coal on which this boiler had been previously run and tested:

Carbon	71.62 per cent.
Hydrogen	5.15 " "
Sulphur	.92 " "
Oxygen and nitrogen	11.51 " "
Ash	10.30 " "
Moisture	.50 " "
	100.00 per cent.

The number of heat units per pound of coal was 13,617.7 B. T. U. Or, theoretically, 20 cubic feet of natural gas used was equal to one pound of this coal, or 40,000 cubic feet equal to one ton. Two analyses were made, which checked with each other, showing that the gas was of the above composition.

The method of firing the furnace was through a manifold, which had seven fingers ¾-inch in diameter, alternating with seven fingers one inch in diameter. The pressure was measured by water gauge, the average pressure being 3.13 inches of water. The amount of gas used was 101,515 cubic feet.

WATER.—The water used was measured in two barrels, first barrel being filled until the tell-tale ceased dripping, when it was emptied into a second barrel and then fed into the boiler with a Mack Injector. The weight of water by scale and by this method we compared, and found results to agree within less than a pound. Injector used steam from boiler tested. The total water evaporation was 50,700 pounds. At the start of the test, the height of the water in the water gauge was noted by a band around the gauge. At the close of the test the water was brought to this mark. Analysis made of the gas taken



SICILIAN ASPHALT PAVING CO., NEW YORK CITY
300 H. P. CAHALL VERTICAL BOILERS

from the stack during the test showed the following results:

Carbon dioxide	5.90 per cent.
Carbon monoxide	None
Oxygen	5.30 per cent.
Nitrogen, Sulphur dioxide, Aqueous vapor, ...	88.80 " "
	100.00 per cent.

STEAM PRESSURE.—The steam pressure at the start was 106½ pounds; at the close it was 105 pounds; the average pressure being 104.9 pounds.

CALORIMETER TESTS.—Calorimeter tests were made at intervals through the test, showing, as an average, that the steam was superheated to 73.8 degrees Fahrenheit.

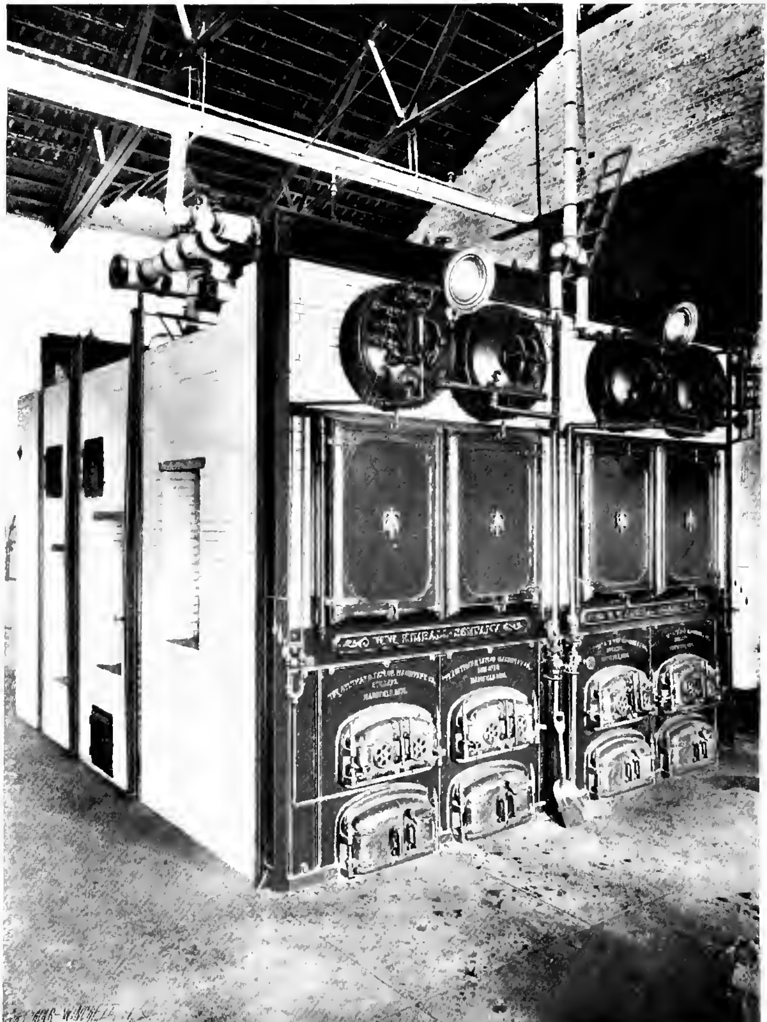
The steam for the calorimeter tests was taken from the main steam pipe, at a distance of about eight feet from the boiler. The pipes were not lagged. When the steam was allowed to blow into the air, no condensation was observed for a distance of six feet, clearly showing that the steam was superheated to a high degree.

The calorimeter used was an ordinary barrel calorimeter; the weight of condensing water being about 300 pounds, and the amount of steam condensed being from five to ten pounds. The scales were read within one-eighth of a pound.

CORRECTIONS.—The barometer used was an aneroid, which was corrected by the Weather Bureau. Thermometers and steam gauge were all tested and corrected before the test.

OBSERVATIONS.—Observations were taken every fifteen minutes during the eleven hours, and the average of these used in the results obtained.

Attached are the complete results of the test. The results show that this boiler is equally adapted to the



W. W. KIMBALL CO., PIANO AND ORGAN FACTORIES
435 H. P. CAHALL HORIZONTAL BOILERS

use of coal or gas. Probably a much better test would have been shown (although this one is in our minds very satisfactory indeed) if the natural gas used had contained a less percentage of free nitrogen, or the coal a less percentage of ash. From the rapidity with which this boiler made steam, and from the temperature of the gases in the stack, we think in this particular case the boiler could be of somewhat larger size for this furnace to utilize economically the waste gases.

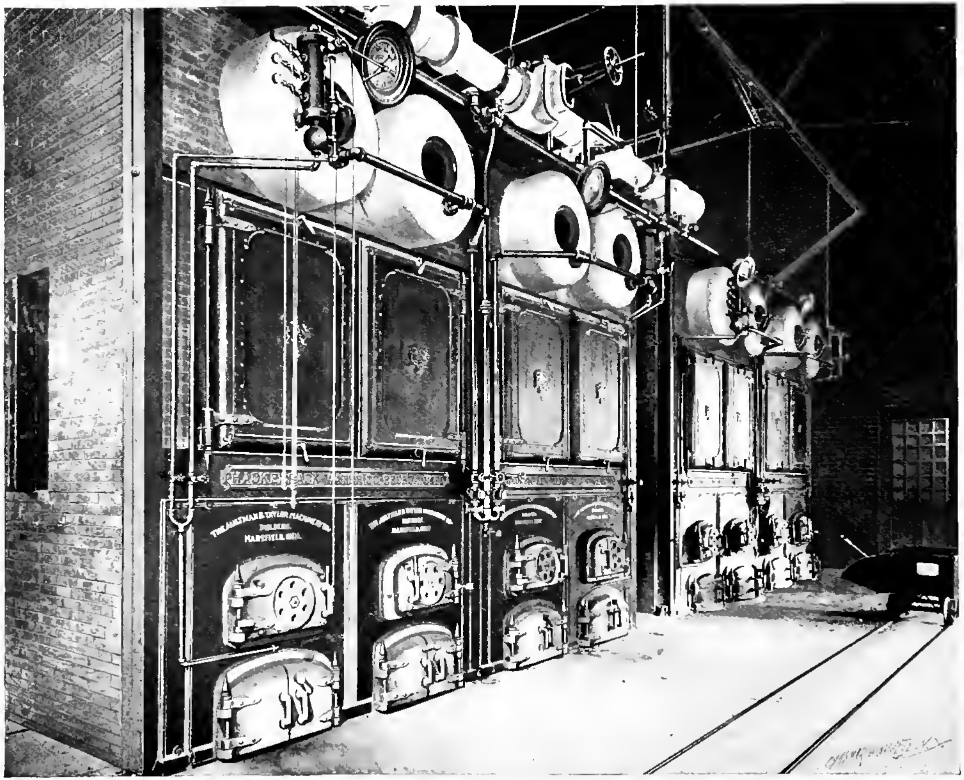
One of the most notable features about this boiler is the extremely small amount of room which it occupies, taking but little more room than an ordinary stack.

Considering the size, simplicity, low cost, its equal adaptability for coal or gas, and its economical steaming properties, it is without doubt the best boiler for its purposes which has come under our observation, and we recommend it cheerfully for all iron and steel works.

It is interesting to note, in connection with this test, the results in tests by other parties. We know of but very few comparative tests which we have made of the consumption of gas to that of coal under the same boilers, with the conditions as nearly similar as possible. The only comparative tests we know of are those of the Engineers' Society of Western Pennsylvania, and the tests of the Allegheny County Light Company and the Allegheny Gas Works.

The number of cubic feet of gas required to evaporate one pound of water, from and at 212 degrees Fahrenheit, as found by tests at the Allegheny Gas Works, was 1.33, 1.37, 1.39 and 1.78, and those of the Allegheny County Light Company, 1.43, 1.78 and 1.50. Our test showed that to evaporate one pound of water, from and at 212 degrees Fahrenheit, it took 1.686 feet of gas.

It must be borne in mind that on these other tests the gas was burned directly under the boilers and had



HACKENSACK WATER CO., HOBOKEN, N. J.
1,000 H. P. CAHALL HORIZONTAL BOILERS

no other work to do, while in our test the gas first had to heat 25,300 pounds of iron, and that the gas itself had a much less theoretical calorific value.

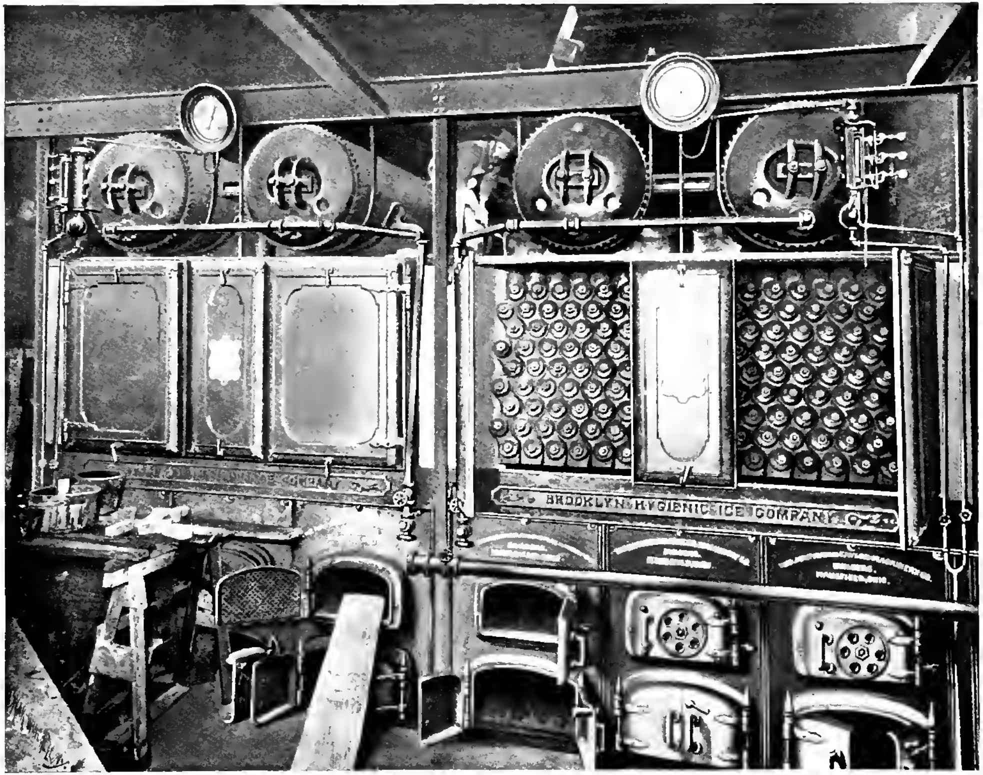
In a series of tests made by the Fuel Gas & Electrical Engineering Company, theoretically, it required nearly 1,000 cubic feet of gas to evaporate as much water as 55 pounds of coal, or 36,360 cubic feet of gas equal to one ton of coal.

S. A. Ford, of The Edgar Thomson Steel Works, after his long series of well-known experiments, determined that 1,000 cubic feet of gas was equivalent to 54.4 pounds of coal, or 36,760 cubic feet of gas equal to one ton of coal; and in our own case, we obtained by analysis that 1,000 cubic feet of gas was equal to 50 pounds of coal, or 40,000 cubic feet of gas equal to one ton of coal. It is thus clear that the quality in this case is much below that commonly used elsewhere.

From the above it will be seen that this boiler, using the waste gases from a re-heating furnace, is very nearly equivalent to the other boilers noted, which burned the gas directly underneath them.

This is no doubt due to the fact that they are not so well adapted to the use of gas as fuel as the Cahall boiler. This is only natural, as the best results are obtained with long tubular or return tubular boilers, for in case of short boilers there is too little space between the flues, and between the flues and top shell—that is, they get very little advantage from the waste gases; and no doubt if a pyrometer test had been made of the escape gases in the tests noted above, a very high temperature would have been shown.

Description of Boiler.—One 125 horse power Cahall Vertical Water Tube Boiler; diameter of steam drum, 60 inches; height, 80 inches; diameter of mud drum, 78 inches; height, 42 inches; diameter of up-take through mud drum, 38 inches; number and diameter of



BROOKLYN HYGIENIC ICE CO., BROOKLYN, N. Y.
636 H. P. CAHALL HORIZONTAL BOILERS

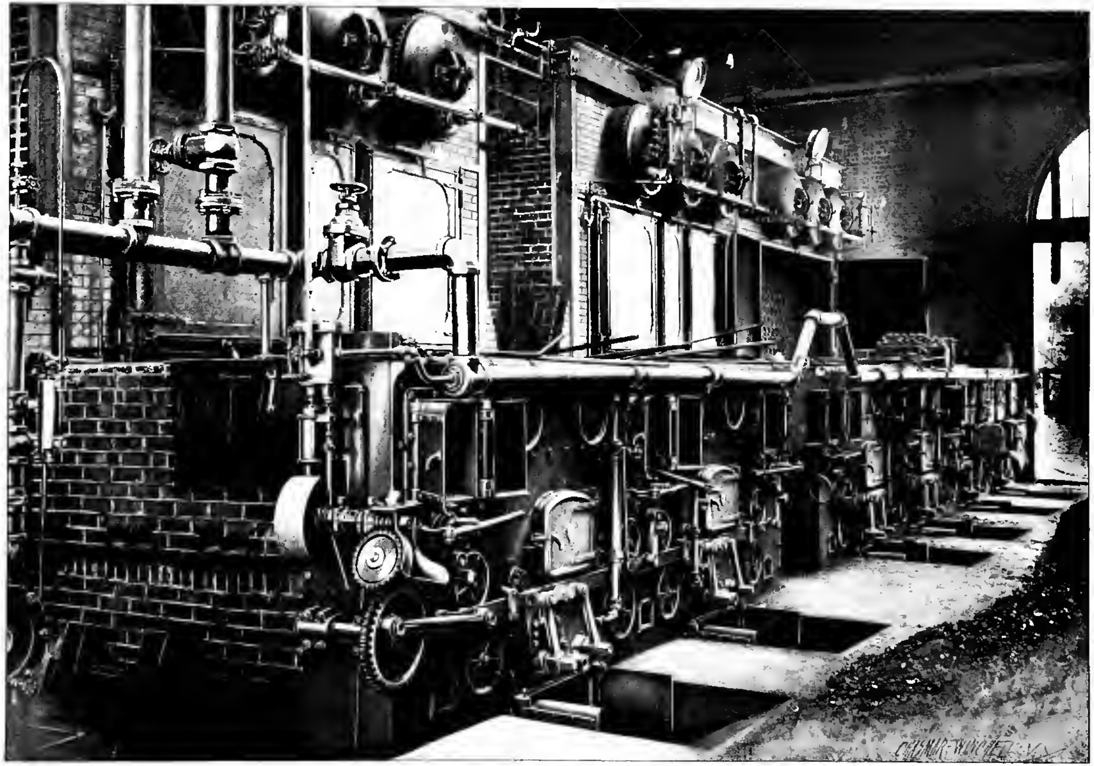
flues, seventy-two 4-inch and six 5-inch. Duration of test, 11 hours.

Square feet of heating surface		1,332.4
Kind of fuel used (analysis given)		Natural Gas.
Cubic feet of gas		101,515
Cubic feet of gas per hour		9,228.6
Average steam gauge pressure		104.9 lbs.
Average steam absolute pressure		119.34 lbs.
Average draft pressure, inches of water		0.40 in.
Average gas pressure, inches of water		3.13 in.
Average barometer	29 4″=	14.43 lbs.
Average temperature of feed water		71.16° F.
Average temperature of outside air		86.6° F.
Average temperature of boiler room		100.1° F.
Quality of steam, dry taken as unity (superheat)		73 8° F.
Pounds of water evaporated (actual conditions)		50,700
Pounds of water evaporated (actual conditions) per hour		4,609.1
Pounds of water evaporated (actual conditions) per 1,000 cu. ft. of gas		499.32
Pounds of water evaporated (actual conditions) per 1 cu. ft of gas		0.4993
Pounds of water evaporated from and at 212° F. per 1,000 cu. ft. of gas		592.79
Pounds of water evaporated from and at 212° F. per 1 cu. ft. of gas		0.593
Cu. ft. of gas required to evaporate 1 lb. of water (actual conditions)		2.002
Cu. ft. of gas required to evaporate 1 lb. of water from and at 212° F.		1.686
Pounds of water evaporated, actual conditions, per 1 lb. of combustible, by analysis, equivalent of gas		9.989
Pounds of water evaporated, from and at 212° F., per 1 lb. of combustible, by analysis, equivalent of gas		11.859
Pounds of water evaporated per sq. ft. heating surface per hour		3.46
Horse power actually developed		153.64
Horse power from and at 212° F.		182.41
Centennial Standard		158.6
Rated		125
Per cent above rated capacity, actual		22.91
Per cent above rated capacity, Centennial		26.88
Sq. ft. of heating surface per horse power, actual		8.67
Sq. ft. of heating surface per horse power, Centennial		8.40

BLOCK PLANT ELECTRIC LIGHT CO., BOSTON
154 H. P. CAHALL HORIZONTAL BOILER

Summary of Twenty Tests Made on Cahall Vertical Boilers

Location.	Date.	Engineer.	Rating.	H. P. developed	Duration of test in hours.	Evaporation per lb. combustible from and at 212° F.	Moisture in steam, per cent.	Superheat in steam, degrees F.	Per cent. developed. Above rating.	Per cent. developed. Below rating.	Kind of Fuel.
Aultman & Taylor, Mansfield, O.	Oct. 1, 1892	R. B. Day	55	81.5	8.00	11.30	....	12.0	50.5	....	Pittsburgh run of mine.
Republic Iron Works, Pittsburgh, Pa.	June 2-3, 1893	Pgh. Testing Laboratory	125	158.6	11.00	11.85	....	73.8	26.8	....	Natural gas.
Sharon Iron Co., Sharon, Pa.	April 26, 1895	A. B. Bellows	200	200.5	10.00	11.28	1.32	......	.25	....	Blast fur. gas and slack.
Salem Iron Co., Leetonia, O.	May 10, 1895	"	250	259.5	10.00	12.92	.40	......	3.8	....	" " " Cherry Val. slack.
Michigan Alkali Co., Wyandotte, Mich.	Aug. 16, 1895	R. B. Day	500	625.2	8.00	10.74	....	6.0	25.0	....	Bituminous slack.
Armstrong Cork Co., Pittsburgh, Pa.	Jan. 9, 1896	R. W. Hunt & Co.	250	353.4	9.00	11.43	....	......	41.0	....	N. Y. & C. nut coal.
Dilworth Paper Co., New Castle, Pa.	Jan. 14, 1896	R. B. Day	400	535.8	6.00	10.51	....	7.3	33.9	....	Pittsburgh slack.
Armstrong Cork Co., Pittsburgh, Pa.	Jan. 16, 1896	J. F. Swan	250	390.2	3.30	10.54	....	No test	59.6	....	N. Y. & C. run of mine.
			250	330.9	3.30	11.58	....	"	32.6	....	" "
Carrie Furnace Co., Rankin Station, Pa.	Jan. 31, 1896	Pgh. Testing Laboratory	250	318.1	12.00	11.54	1.16	......	28.5	....	Blast furnace gas.
Armstrong Cork Co., Pittsburgh, Pa.	April 22, 1896	Armstrong Cork Co.	250	278.4	9.00	11.14	....	No test	11.3	....	Summer Hill nut and slack.
" " " " "	April 23, 1896	" " "	250	463.5	9.00	10.85	....	"	85.4	....	" " " "
" " " " "	May 4, 1896	Thos. Pray, Jr.	250	257.5	9.00	13.96	....	40.2	3.0	....	" " slack.
" " " " "	May 5, 1896	"	250	416.0	9.00	11.71	....	26.5	66.4	....	" " "
Jones & Laughlins, Ld., Pittsburgh, Pa.	June 10, 1896	Jones & Laughlins	250	458.0	8.00	11.09	....	No test	83.0	....	Pittsburgh slack and nut.
Traders Paper Co., Lockport, N. Y.	June 24, 1896	R. B. Day	500	628.0	8.00	12.51	....	......	25.6	....	Bituminous slack and pea coal.
Armstrong Cork Co., Pittsburgh, Pa.	Aug. 11, 1896	J. M. Whitham	250	281.5	12.00	11.81	....	4.3	12.7	....	N. Y. & C. Sandy Creek.
" " " " "	Aug. 12, 1896	"	250	501.8	10.00	11.24	....	4.8	100.7	....	" " "
Phila. & Reading Coal and Iron Co., Branchdale, Pa.	Sept. 30, 1896	"	250	230.9	8.25	11.26	....	3.5	......	7.6	Anthracite culm (55 per cent. combustible).
Merrimac Mfg. Co., Lowell, Mass.	Dec. 31, 1896	E. F. Miller	250	257.6	34.00	11.75	....	5.17	3.0	....	George's Creek.
Averages			264	351.7	.....	11.55	....	......	36.48	....	



CINCINNATI STREET RAILWAY CO.
1,000 H. P. CAHALL HORIZONTAL BOILERS

"Flowed" Steel

It having come to our notice on several occasions recently that some of our competitors in the manufacture of water tube boilers have been offering to the general public headers or manifolds and cross-boxes which are claimed to be made of "flowed" steel, we desire to call attention to the fact that "flowed" steel is a special mix of open hearth steel manufactured under a secret formula which belongs to us alone, the knowledge of the preparation of which is in the possession of no one except the Penn Steel Casting & Machine Co., of Chester, Pa., and as any one offering either headers, cross-boxes or flanges made of "flowed" steel is doing so with intent to deceive the public, we publish the foregoing statement and, in addition, the accompanying letter written to the Penn Steel Casting & Machine Co. by our general Eastern agents, and their answer to the same.

CAHALL SALES DEPARTMENT

OFFICE OF THAYER & CO., INC., DREXEL BUILDING
PHILADELPHIA, PA., January 21, 1897

Penn Steel Casting & Machine Co., Chester, Pa.

GENTLEMEN: We have information that certain parties are claiming to be able to furnish—in fact, offer to furnish with their boilers—headers and other parts of "flowed" steel.

As "flowed" steel is of a special mixture and our property, we would ask if you have ever furnished or are now furnishing "flowed" steel headers to any party or parties other than ourselves?

An early reply will oblige. Yours truly,

(Signed) THAYER & CO., INC.

OFFICE OF PENN STEEL CASTING & MACHINE CO.
CHESTER, PA., January 21, 1897

Messrs. Thayer & Co., Inc., Drexel Building, Philadelphia

GENTLEMEN: Referring to your inquiry of even date, we beg to state that we consider the special mixture for flowed steel we are making

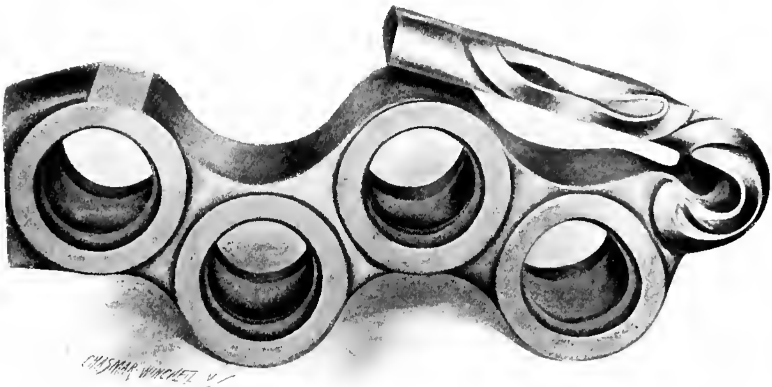
WILLIMANTIC LINEN CO., WILLIMANTIC, CONN.
750 H. P. CAHALL HORIZONTAL BOILERS

for you your property, of which you have the sole right, and that we never have nor never will furnish flowed steel to any one but yourselves, unless authorized by you. Neither will we give to any one any information as to the formula mixture of which this special mixture is made.

Yours respectfully,

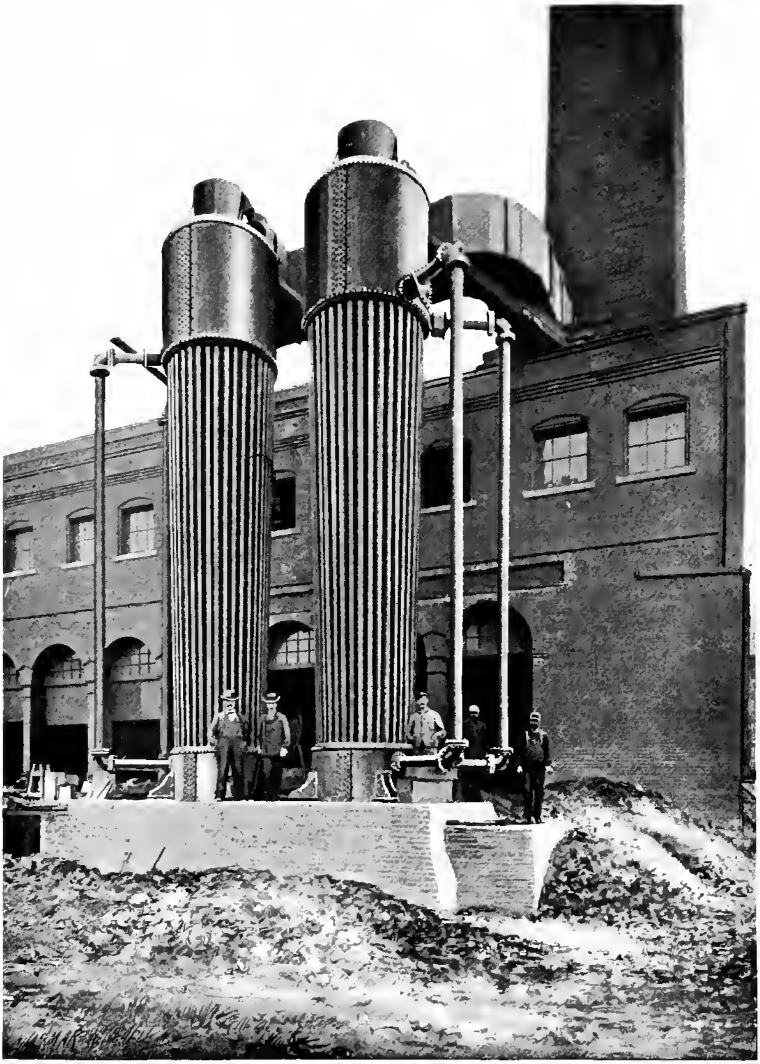
PENN STEEL CASTING & MACHINE CO.

(Signed) FRED. BALDT, Manager.



"FLOWED" STEEL HEADER

Hammered flat at one end and doubled back on itself without cracking

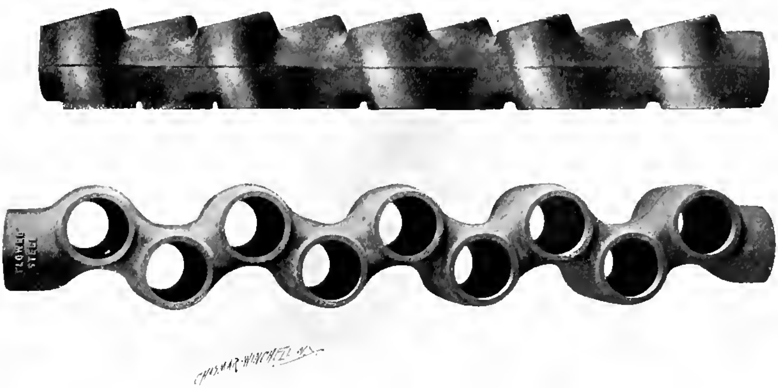


HUDSON ELECTRIC LIGHT CO., HOBOKEN, N. J.
500 H. P. CAHALL VERTICAL BOILERS

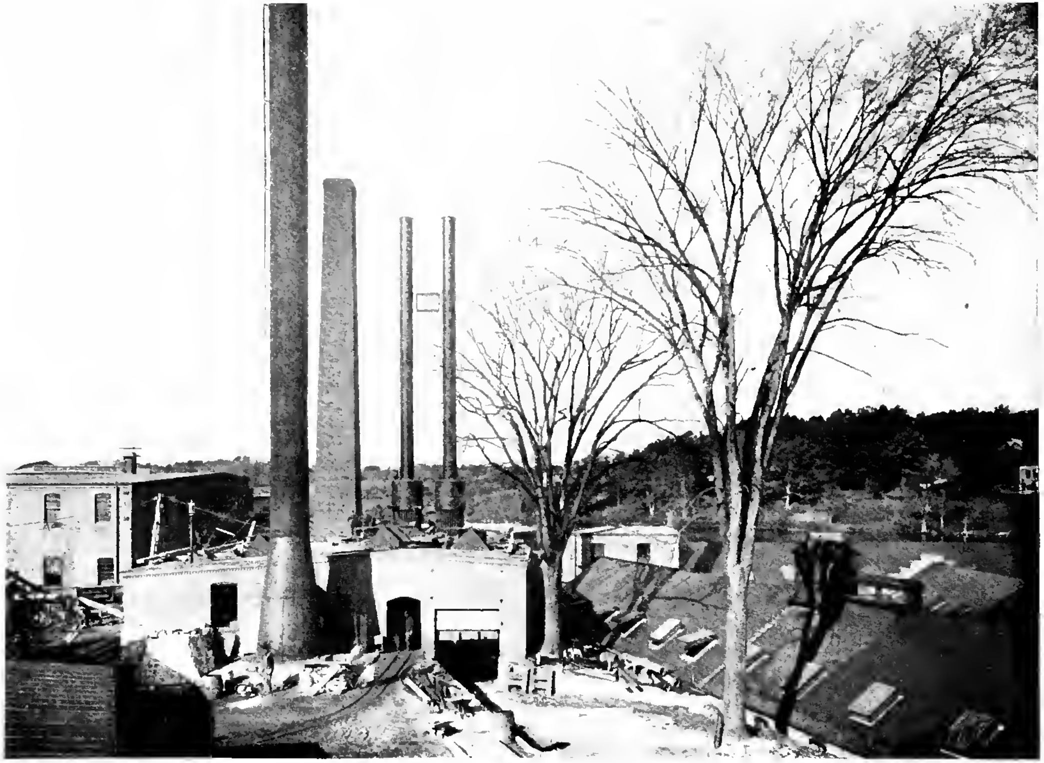
Vertical Headers for Cahall Horizontal Boilers

The only object in using a header of this type is to economize space where a horizontal type of boiler is used. A header of this design enables us to install the series of headers at right angles to the steam and water drums overhead, instead of inclining them.

Many points of advantage have been claimed by competitors of ours for this vertical type of header, nearly all of which are purely theoretical and are "selling points" mainly. The only valid advantage that can be claimed for this construction under any circumstances is the difference in room occupied, which amounts to about two feet in length for a 250 horse power boiler.



VERTICAL HEADER



F. W. BIRD & SONS, EAST WALPOLE, MASS.
500 H. P. CAHALL VERTICAL BOILERS

Capacity of Boilers

BY S. C. MUNOZ

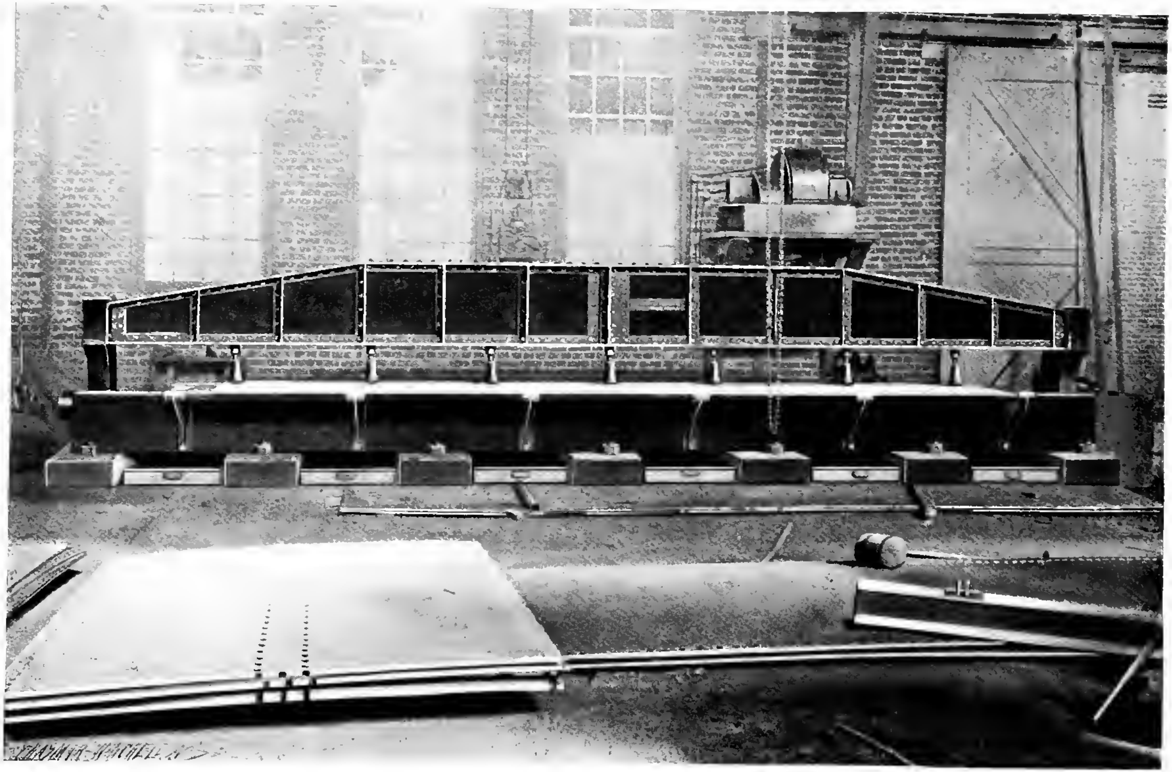
The methods of determining the capacity of a boiler at the present time seem to be in a more chaotic condition than when in 1876, during the Centennial Exhibition, the American Society of Mechanical Engineers adopted a standard as to what should constitute the horse power of a boiler.

Watts demonstrated or created a fixed rule as to what should constitute a horse power of a steam engine, which rule has been applied to all types of power generators.

Previous to 1876 the boiler was rated in accordance with the engine, and the boiler was called as many horse power as it was capable of developing power as indicated at the engine.

The quantity of steam required by the different engines varies to such an extent that in fairness to the boiler, and in order to be able to demonstrate the power of a boiler independent of the engine, the American Society adopted the rule that 30 pounds of water evaporated from feed water temperature of 100 degrees Fahrenheit into dry steam at 70 pounds pressure would be considered the equivalent of a horse power, or, in other words, that this amount of steam should be capable of exerting sufficient energy to raise 33,000 pounds one foot per minute.

Since that time the improvement which has been made in the manufacture of engines, and the demand for large powers to be placed in small spaces, has wrought considerable change, and where a few years ago in our largest manufactories and power plants it was seldom that engines were found requiring steam pressure of over 100 pounds (and in a majority of cases it would be 80),

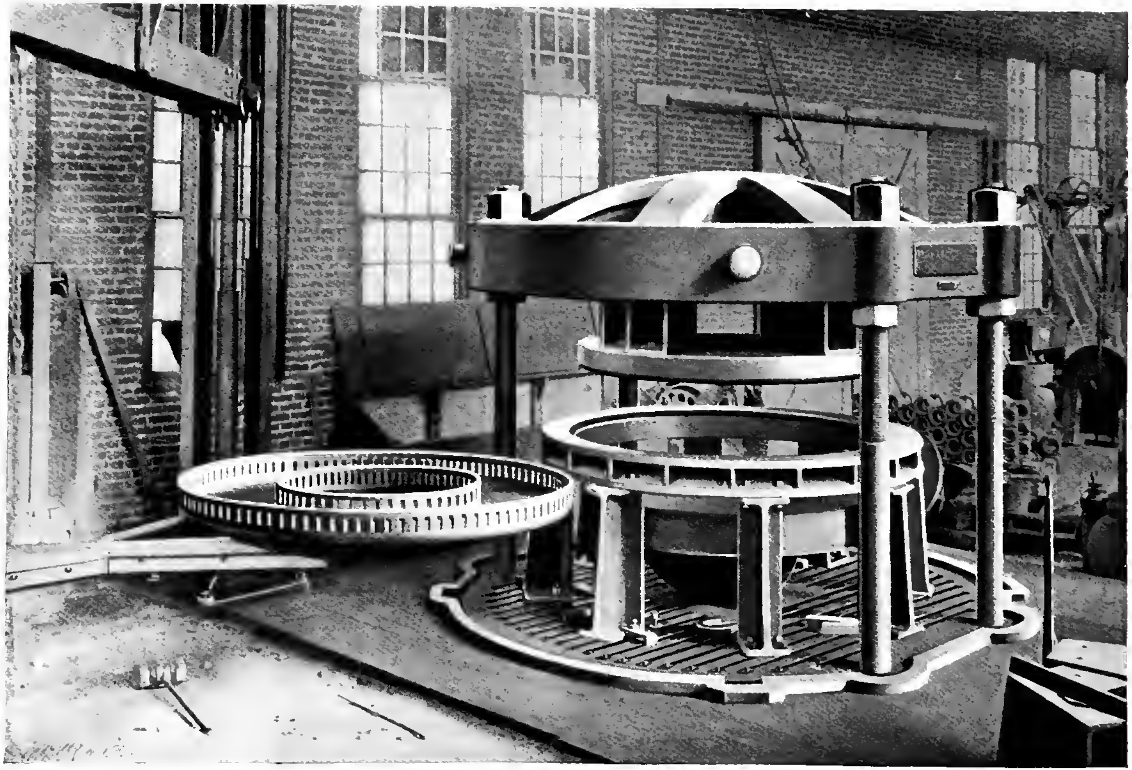


MACHINE FOR BEVELING PLATES, CAHALL FACTORY

modern plants of to-day are running simple engines at 100 to 115 pounds pressure and compound condensing engines from 115 to 150, and occasionally as high as 160 pounds pressure. We also find that where a very few years ago steam plants were operated requiring from 25 to 40 pounds of water per horse power, to-day the larger and better equipped plants are operating their engines with from 13 to 18 pounds of water per horse power. To this can be added a small percentage for operating water and air pumps, or the necessary auxiliaries for the compound condensing plants, with a slight increased requirement of steam.

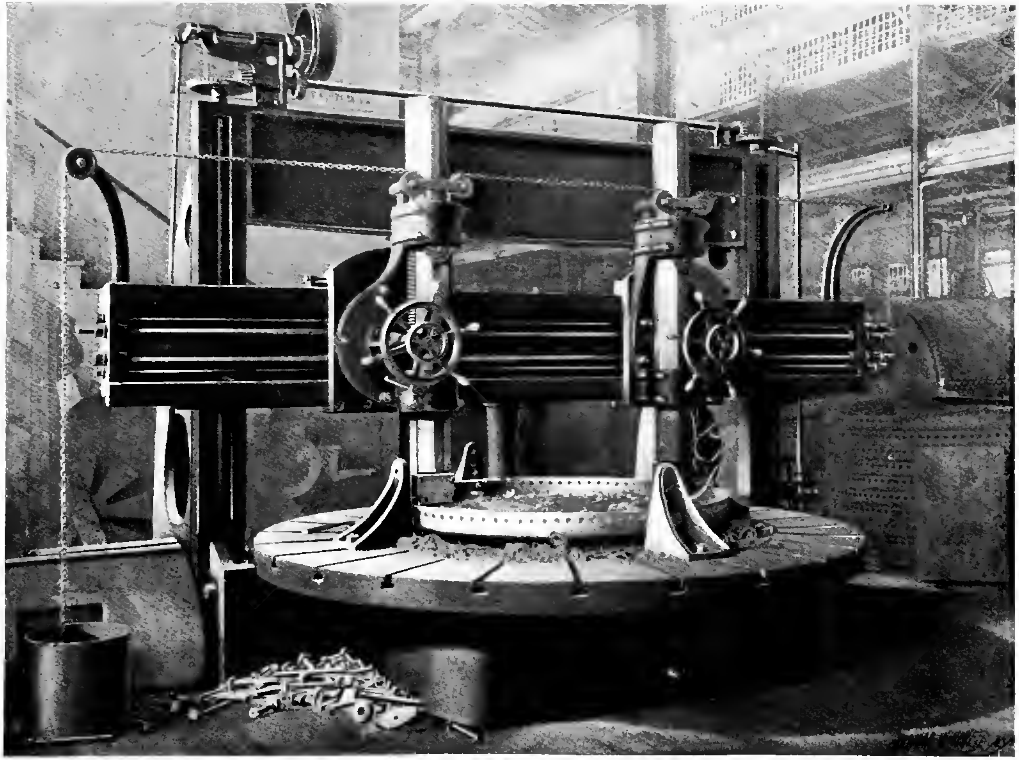
The total steam consumption in a modern plant will not exceed for engines and auxiliaries 20 pounds of water per horse power, where such plants are run compound condensing. As this is the type of engine that the water tube boiler manufacturers come mostly in contact with, it is very readily seen and demonstrated that 1,500 horse power of such engine requires but two-thirds of a like amount in boiler capacity, using the American Society rating for the boilers; so that when one purchases a 1,500 horse power compound condensing engine, 1,000 horse power of boilers in four units will be ample to run this engine economically and at the same time give one unit of boiler power to keep in reserve for cleaning and repairing without interfering with the operation of the plant.

In order to have the boiler plant equally as economical and as well proportioned as the engine, it is necessary to take other things into consideration which affect absolutely its economy or efficiency. There are three vital points, aside from the design and workmanship of the boiler. First, the proportion of grate to heating surface, which proportion should be determined by the character and kind of fuel to be used; second, the draft in the chimney, and the



HYDRAULIC FLANGING PRESS, CAHALL FACTORY

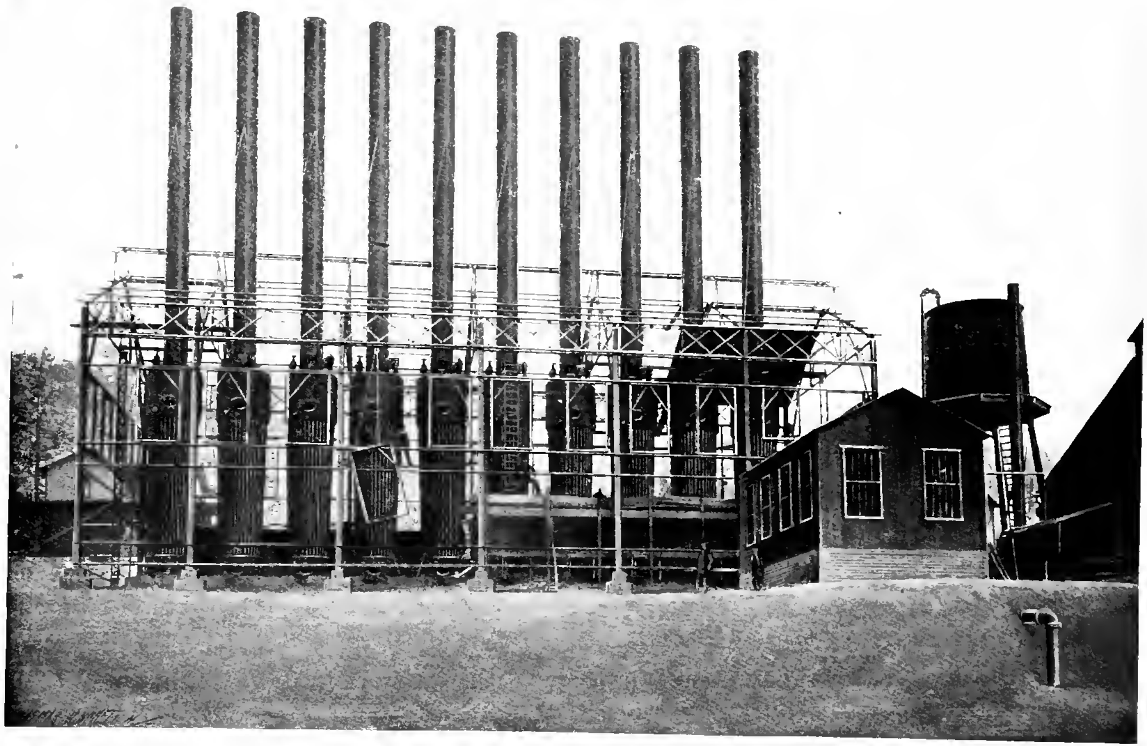
flue connecting boiler to same; and third, the type of furnace. Taking these three items in rotation, by referring to coal tables we find that in the different coal districts the quality and character of the fuel mined varies to a very great extent. We find the fuel running from a light lignite to a heavy anthracite; the former a free burning fuel, the latter a fuel which at the best can be burned but very slowly, comparatively. We find in anthracite coal, according to the size and mines from which it comes, a difference of as high as 25 per cent. in its evaporative strength. In bituminous coal the difference is still greater. We find a bituminous coal mined in Illinois containing as low as 9,000 heat units, with a theoretical evaporative efficiency of 9.35 pounds of water from and at 212 degrees per pound of coal, as against a cannel coal in Kentucky containing 15,100 heat units, with a theoretical evaporative efficiency of 16.76 pounds of water from and at 212 degrees per pound of coal; in Iowa a coal containing 8,700 heat units, with a theoretical evaporative efficiency of 9 pounds of water per pound of such coal; another in West Virginia containing 14,200 heat units which has an evaporative efficiency of 14.17 pounds of water per pound of coal. These different fuels, ranging from the anthracite coal running 80 per cent. of fixed carbon and 3 to 4 per cent. of volatile matter, to the highly volatile bituminous coal running as low as 30 per cent. in fixed carbon and as high as 45 per cent. in volatile matter, require entirely different draft conditions and an entirely different type of furnace in order to obtain the best results from either. The high-carbon coal, with its non-caking qualities, requires a grate bar with small openings, to prevent the loss of good fuel through same. It requires a high stack, in order to have a high draft pressure, that the air may be pulled through the small openings, and the hard, slow-burning carbon be kept



ONE OF THE ELECTRICALLY DRIVEN BORING MILLS, CAHALL FACTORY

burning with its exceedingly short flame and intensely local combustion; as much of the effective part of the heating surface of the boiler as possible needs to be brought into as close contact with the point of combustion of the fuel as is found practicable; whereas the highly volatile coal, on account of the strong caking qualities of the fuel, requires a grate with large openings (it is understood, of course, that these openings are well and equally distributed), and requires a stack of larger area on account of the enormous volume of gases created by the expansion of the volatile matter due to its combustion. The furnace should be of a type and design to allow thorough combustion and expansion of these volatile gases before coming in contact with the cool surface of the boiler, and at the same time not be carried so far before coming in contact with the heating surface of the boiler as to lose in temperature by radiation through brick wall or absorption by the ground. The stack should be amply high to give sufficient strength of draft to pull through the furnace the enormous amount of air required for the proper ignition of the volatile gases.

We have now two points to consider, the first a fixed quantity, viz., that the efficiency of a boiler is determined in general by the initial temperature of the gases, or, in other words, the temperature of the gases where they first come in contact with the heating surface of the boiler, and the terminal temperature of the gases, or the temperature at the point where the gases leave the boiler. We have stated what in our judgment would assist in attaining the highest initial temperature with either bituminous or anthracite coal. The next question to consider is the volume of these gases, and as the volume obtainable is due to the amount of grate surface which you have under the boiler, after your stack and furnace have been fixed, we can begin to reach the

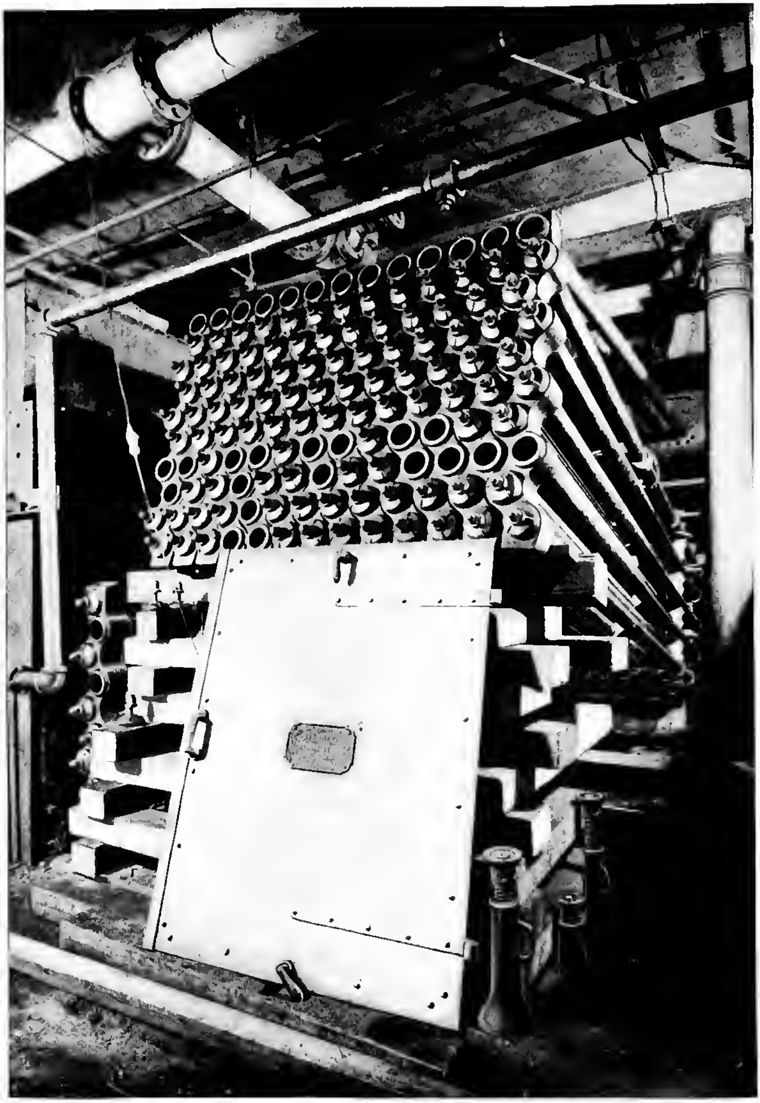


2,000 H. P. CAHALL VERTICAL WATER TUBE BOILERS AT CARNEGIE NATURAL GAS CO.'S STATION, BAGDAD, PA.

conclusion of what proportion of grate surface we should have to heating surface. Taking as a standard a stack that will give an inch draft regardless of the quality of the fuel that is used, and we start with an anthracite buckwheat coal, with a theoretical evaporative efficiency of 12.63 pounds of water per pound of such coal; further assuming that our furnace and grates are as they should be, and we can therefore obtain an efficiency of 70 per cent. of this fuel, we find that each pound of fuel will evaporate 8.84 pounds of water from and at 212 degrees per pound of such fuel; as 34½ pounds of water from and at 212 degrees is equivalent to a horse power, it will require 8,625 pounds of water to equal 250 horse power of boilers, or 975 pounds of fuel per hour for each 250 horse power. It has been demonstrated that the best economy, with such fuel and under the conditions as above stipulated, can be obtained while burning from 14 to 18 pounds of coal per square foot of grate; taking 16 as an average, we come to the very plain conclusion that each 250 horse power boiler should have 61 square feet of grate surface in order to develop 250 horse power with an average anthracite buckwheat coal with the best economy obtainable from same. We find, by the same method of calculation, using a highly volatile bituminous coal with a theoretical evaporative efficiency of 11 pounds of water from and at 212 degrees, with draft and furnace properly designed, and it having been demonstrated that while burning 24 to 28 pounds of coal per square foot of grate the best results are obtained from this fuel, as follows: water per pound of coal, 7.70; 8,625 ÷ 7.70 = 1,120 pounds of coal per hour; divided by 26 gives 43 square feet of grate surface required to develop 250 horse power. Next take a New River coal with a theoretical evaporative efficiency of 14.70, and assuming the same percentage of utilization, we find that one pound of this coal is capable of evaporating 10.29 pounds of water from

REVERE RUBBER CO., CHELSEA, MASS.
USING 1,500 H. P. CAHALL VERTICAL BOILERS

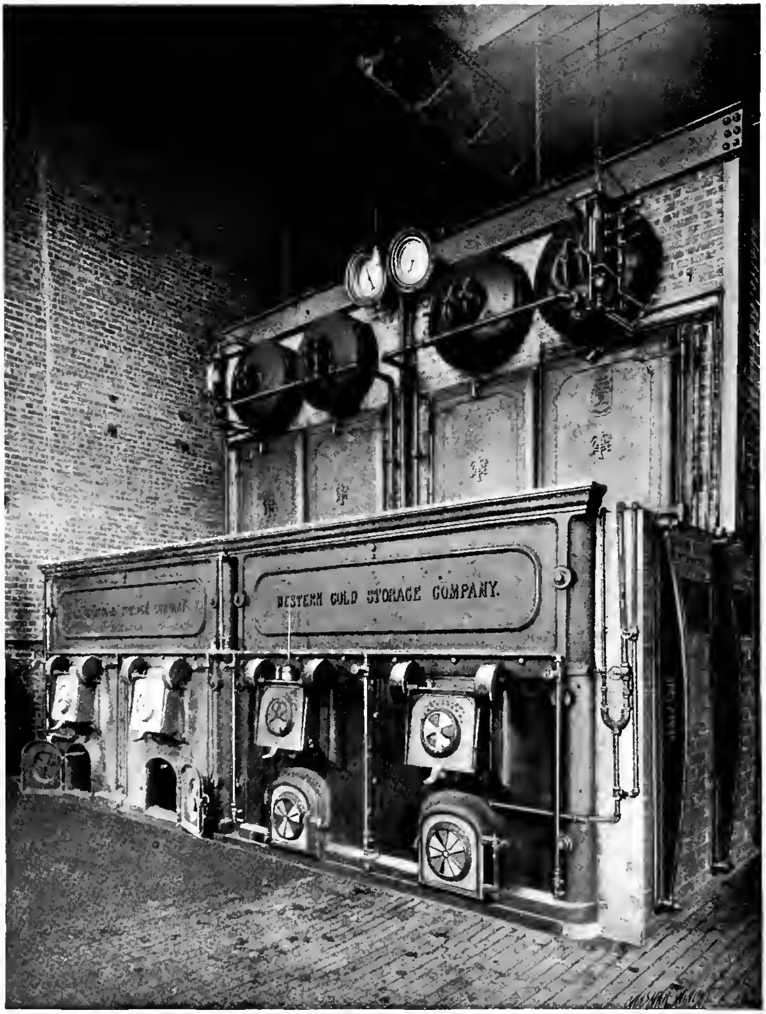
and at 212 degrees per pound of fuel; then, 8,625 ÷ 10.29 = 838 pounds of coal per hour, with proper draft and furnace, to obtain best results; and burning 22 pounds of coal to square foot of grate, we find 38 square feet of grate required. From this it can be readily seen that a boiler designed for 250 horse power, and assuming a standard of 10 square feet of heating surface required per horse power, reached apparently by general consent, has been adopted by the leading water-tube boiler makers of the country. The anthracite buckwheat coal should be proportioned on a basis of 40 square feet of heating surface to one square foot of grate surface. The volatile and free burning bituminous coal should have 56 square feet of heating surface per square foot of grate surface; and with the strong West Virginia, Pennsylvania, Virginia and Maryland bituminous coals we should have 2,500 ÷ 38 = 66 square feet of heating surface per square foot of grate surface; and boilers properly designed for the anthracite regions, in order to obtain the best results, would be entirely out of proportion in grate surface in order to obtain the best results with either a low grade or high grade bituminous coal, or *vice versa*. The requirements of the draft conditions for the same make of boiler, constructed under different proportions, will vary as much as will the grate surface. This is determined by the height of the rows of tubes, as the more feet of surface the gases have to pass at right angles, the greater the friction, therefore the more pull required to carry the gases over same effectively. The points which we wish to bring out particularly in order to get the best results, are enumerated above. Consider the fuel to be used, the local conditions and the draft that can be secured under them, the properly constructed furnace, and a heating surface between the furnace and the stack so placed and proportioned as to enable the obtaining of the highest initial temperature at the point



JORDAN, MARSH & CO., BOSTON, MASS.
CAHALL HORIZONTAL CROSS DRUM BOILER

of coming in contact with said heating surface, and a terminal temperature as low as the pressure carried in the boiler will allow. This terminal temperature should be at least 125 degrees, and not to exceed 200 degrees, above the steam temperature.

CITIZENS' GAS CO., BRIDGEPORT, CONN.
330 H. P. CAHALL VERTICAL BOILERS



WESTERN COLD STORAGE CO., CHICAGO, ILL.
500 H. P. CAHALL HORIZONTAL BOILERS

Superheat

BY R. S. HALE

During the last few years engineers have begun to appreciate how great a reduction of the engine waste, known as initial condensation, can be obtained by using superheated steam, and there are authentic experiments on record showing a gain due to superheating of 70 per cent. more work from the same quantity of steam, while the average gain from superheat, as shown by a great number of experiments, is 4 per cent. gross for each 20 degrees superheat, or 3 per cent. net after allowing for the 1 per cent. necessary to superheat steam each 20 degrees. This saving is in comparison with absolutely dry steam, while commercial steam may contain 2 per cent. moisture and often does contain more, making a correspondingly greater saving.

In consequence, engineers have in many cases put in special superheating apparatus requiring special valve systems, and sometimes a whole special installation, in order to superheat the steam.

Special superheaters, however, involve additional cost, additional complication, and in some cases special care in their operation in order to prevent injuries and accidents when steam is being raised. On the other hand, some of the vertical types of boiler, among which is found the Cahall water tube boiler, superheat the steam by heat in the gases which would otherwise be wasted, thus saving the heat necessary to superheat the steam, and making the total gain 4 per cent. for each 20 degrees instead of 3 per cent. In addition, which is more important, this boiler does not have the complication involved by special superheating apparatus.

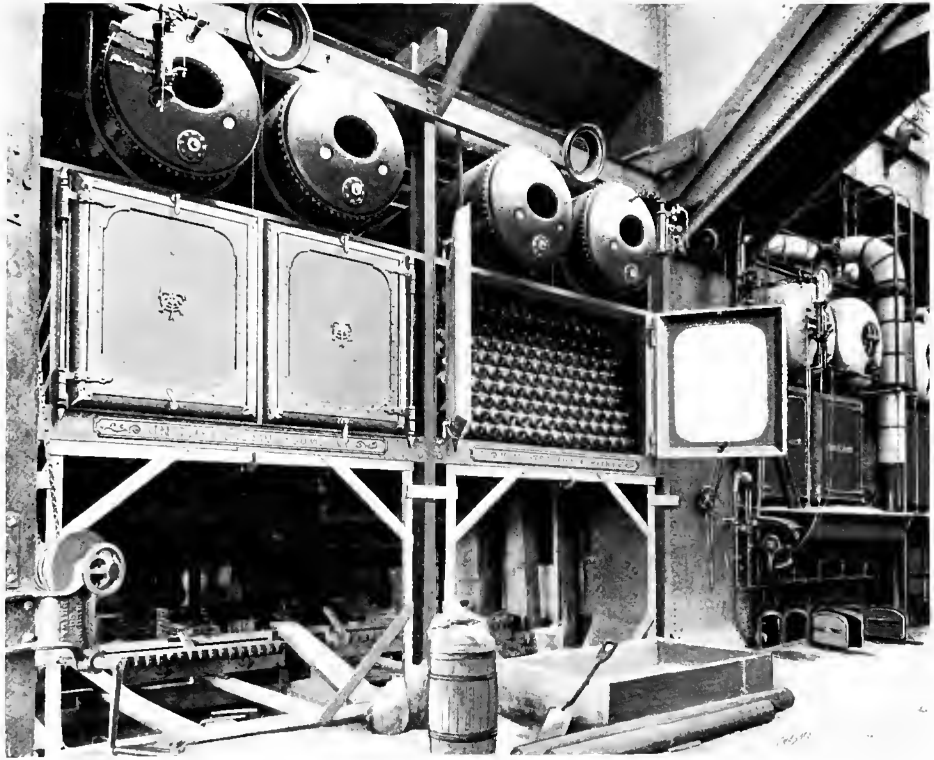
Besides this, many good engineers consider that a small amount of superheat is of much greater proportionate advantage than the high degrees of superheat obtained by use of special apparatus. In any case, the

PLANET MILLS, BROOKLYN, N. Y.
1,000 H. P. CAHALL HORIZONTAL BOILERS

comparison of the superheated steam from the Cahall boiler with ordinary commercial steam is much in favor of the Cahall. In the published series of tests of the Cahall boiler the average superheat was about 20 degrees. The actual true superheat is probably more than this, since, as Prof. Jacobus showed in his paper before the American Society of Mechanical Engineers in 1895, the usual methods of measuring the temperature of superheated steam give a result several degrees lower than the true temperature. Twenty degrees superheat at the engine, if obtained by waste heat, would be 4 per cent more efficient than absolutely dry steam, and 6 per cent. more efficient than commercial steam containing 2 per cent. moisture. The highest degree of superheat reported in the tests was 73 degrees, which if retained at the engine would give a gain of 14.6 per cent. over absolutely dry steam, and 16.6 per cent. over commercial steam containing 2 per cent. moisture.

The makers of the Cahall boiler claim that they have so proportioned their superheating surface that the highest degree of superheat is obtained when the boiler is performing at its rated horse power, running easily. This is an important feature, since, as stated above, the gain due to superheat is on account of the reduction of the engine waste known as initial condensation, and this is much the greatest when the plant is running light, and when in consequence the amount of superheat should be the greatest.

Some of the superheat at the boiler is usually lost on the way to the engine, so that the amount of the saving in any particular case depends on particular conditions, but it is safe to say that a boiler which delivers steam even very slightly superheated to the engine should give better efficiency than boilers delivering only commercial steam, particularly when the superheat is obtained without extra cost, as in the instance of the Cahall boiler.



UNION TRACTION CO., PHILADELPHIA, PA.
CAHALL HORIZONTAL BOILERS